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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 3 **April, 1920** **No. 4**

EDITORIALS

AN ART DIVISION

Only a few years ago the ceramic products made in this country were not particularly remarkable for their beauty. They were good serviceable wares made from first-class material by skilled workmen; but, owing to the lack of judgment in choosing designs and decorations—or rather owing to failure to perceive that the proper choice of design and decoration were important factors in the selling price—the finished products were in many cases quite homely. It is true that such wares found a ready sale among certain classes of people. Up to the present time, this country has been a nation of pioneers; and, like all new nations, it has been interested primarily in producing the things which add to the material welfare and comfort of the people. Aesthetic development comes later in the life of nations. That homely, if not positively ugly pottery, was formerly highly prized in this country is evidenced by memories of the bric-a-brac on the "what-nots" of cold and gloomy "parlors."

In the past twenty years the people of this country have made remarkable strides in the development of artistic taste and appreciation. This is shown in our architecture, our park and boulevard systems, in the dress of the people, and finally in a demand for more beautiful ceramic materials. As examples we may mention the ready sale found by high-grade terra cotta, the phenomenal development of the rough-texture face brick business, and the growth of the art and tableware potteries which have been turning out really beautiful wares.

At no time in the history of this country has the market price of beauty been as high as it is at present. The country is prosperous; thousands of people have the funds that enable them to satisfy the innate craving to possess beautiful objects. They are no longer satisfied to buy objects that are merely good and serviceable. They want them good and serviceable; but at the same time they want them beautiful and are willing to pay the price of beauty. The ceramic firms in this country which are making beautiful wares are finding that the care and expense involved in making their products beautiful instead of simply mediocre are very profitable investments. While there is still a market for homely wares, this market is decreasing; and it is safe to predict that it will continue to decrease very rapidly.

The ceramic industries of this country are second to none in the quality and serviceability of the wares they are manufacturing. If this country is to become one of the leading ceramic manufacturing countries of the world, it is essential that we cultivate the artistic side of ceramics. At the annual meeting in Pittsburgh the Board of Trustees of the American Ceramic Society authorized the formation of a Division devoted to ceramic decorative processes, provided ten members would ask for such a division. Nothing has come of this up to the present; but, for the sake of the best interests of the ceramic industries of this country, the American Ceramic Society should foster the development of the aesthetic phases of ceramics.

Our literature and membership lists disclose that many members of the Society are now working in the field of artistic ceramics—in the production of art pottery, both by factory methods as a business and by hand as an artistic craft, in the production of beautiful designs and glazes for terra cotta and wall tile, and in the designing and decoration of table ware and other ceramic products that must be beautiful as well as useful. It seems feasible to use these members as the nucleus of a potentially important Division devoted to artistic ceramics.

WORK OR QUIT

During the past few years the American Ceramic Society has been more fortunate than most societies in its committee work.

In nearly every case the work intrusted to a committee has been performed promptly and efficiently; and—what is more remarkable—in most cases a large portion of the committee members have actually helped in the work. In a few cases, however, the committees have done little and on every committee there have been a few members who have done nothing.

According to Webster a committee is a group of persons to whom some trust or charge is committed. We publish the names of our standing committees in the JOURNAL periodically, and thus advertise to the Society and to others that these men have undertaken to do certain things for the benefit of the Society. In the minds of the readers the members of these committees are given credit for doing altruistic work in the interest of the ceramic industries of this country. Committee members who do not work and who allow their names to be published in this way are receiving honor and gaining prestige by false pretense. Moreover, there is a sufficiently large number of members of the Society who are anxious to give energetic and faithful service to more than fill every committee. Therefore, these men are really standing in the way of the best interests of the Society. It seems, therefore, that if a member of the Society is appointed on a committee and, for any reason, he does not care to work or is not able to give the necessary service, he should promptly send in his resignation.

ORIGINAL PAPERS AND DISCUSSIONS

THE STORING AND HANDLING OF RAW CLAYS

By T. W. Garve

Purpose of Storage.—We have pointed out in a previous paper[1] that "raw clays are stored for the purpose of sufficient supply during winter or during bad weather; to help over any breakdown at the mine or bank; to secure a better and more uniform mixture; and to improve the working conditions of the clay and the quality of the ware.

"The clay storage equipment should be an independent feature of the plant that can be in use continuously or intermittently, as conditions require, so that all unnecessary rehandling be avoided. It should face the clay bank, and later extension should be possible."

Crushing.—Shales are often crushed before being placed in storage and we have shown such layouts in our illustrations. This, however, may not have any bearing upon the system of storing and handling the clay or shale, hence the methods of storage can be considered by themselves.

If the shale is won by steam shovel there are frequently large pieces to go into the cars, and the sooner they are crushed the better for further handling. Where weathering or mixing are desirable or essential there will naturally be better results if the crushing is done ahead of the storing.

While it is recommendable to crush shales before their storage, it may be difficult to do so in certain cases, for instance, where

[1] "The Designing of Factory Layouts for the Clay Industries," *J. Am. Ceram. Soc.*, **2**, p. 194.

the factory is far from the storage intake and where no electric power is available. This difficulty might be overcome in certain installations by placing the crusher or any other grinding or preparing machinery at the factory end of the storage building where direct drives from the line shaft can be had, and conveying the crushed material backward to storage. In this way the direct use of unstored clay is easily accomplished.

Weathering.—Storing may have but little to do with weathering; and yet, to a certain extent, the process of handling and storing will more or less improve the working conditions of the clay and so the quality of the ware. Considering shales, the pre-grinding will be a factor in favor of the above claim.

It can readily be seen that by the methods of storing and handling we are opening up the raw materials and expose them more freely to the air just as we improve the soil by plowing it. A lot of air is being entrapped within the lumps or particles of shale or clay as they roll down over the storage pile to be rebuilt and repacked.

Mixing.—While there seems to be no real systematic mixing done by using a storage shed and dumping the clay down on piles, the result is often sufficient for practical purposes.

The storage alone would not be a sufficient means of mixing where it is essential to get an average of the clay bank from top to bottom and from end to end, and it will be necessary in such cases to get a mixture at the pit and work the clay or shale bank accordingly, by a clay digger, or shale planer, or hand method, or any other suitable manner. In any case, the material dumped will spread out in thin sheets over the storage pile, the voids being filled by the new layer, etc. This relaying of the clay bank so to speak, will unquestionably have a mixing effect to a degree determined by the manner of manipulation.

For mixing lengthways, it is an easy matter to have the clay car dump at different places along the shed or to set the tripper ahead at times or to use a continuously moving tripper which discharges along the storage while traveling back and forth. If there is a side discharge from car or belt, the sides can be altered at certain intervals. A certain amount of mixing again

is being done by drawing from storage. For perfect mixing or blending of different clays a method as shown in figure 10 may be used. A number of modifications can be worked out on this principle to suit the particular problem.

Clay to Storage.—The raw material can be taken to storage direct from a dump car, which can have a bottom, side or end discharge, or the car may be emptied by a dumping device. Since a dumping device would be a stationary affair, the dump car is to be preferred since it will permit of delivery at any place along storage. We can accomplish the same thing by the installation of conveyors of various types or, if the storage can be high without extending over a large area, a high elevator with a swivel spout, or distributing spouts might be used, or a rotating elevator. For more specific information see Conveying and Storage Systems.

Clay from Storage.—From storage the material can be carried out either by cars or suitable conveyors. For feeding the material to these, we can use removable boards or spouts or feeders of various types, as reciprocating feeders, disc feeders, or screw feeders. If boards are used, an opening, closed with removable boards, should be left at one end of storage building above the belt to enable the start of emptying a completely filled storage. For more specific information see Conveying and Storage Systems.

Belt Conveyors.—In regard to belt conveyors, the troughing type is used to quite some extent in clay plants, since it does not seem to spill the clay as the flat conveyor does and has greater capacity. However, the flat conveyor has its advantages, especially if used wide enough to prevent spilling of material. While a troughing conveyor will have about 60 per cent more capacity than a flat conveyor of the same belt, the life of a flat conveyor is considerably longer, perhaps half as long again.

The belt should be carried on idlers and not on boards. For a troughing conveyor, all idlers should be cylindrical and the side idlers should be set at an angle to form the trough of the belt, but no conical idlers should be used since their circumferential speed varies, causing rubbing and wear on the belt and shortening

its life. Large head and tail pulleys also will tend to lengthen the life of the belt. The belt speed should be around 125 feet per minute.

Conveying and Storage Systems.—In the accompanying illustrations we have a number of different systems for storing and handling raw clays or shales. Each has its merits and any preference would depend upon conditions, as capacity and location of plant, length of season, kind and quality of ware, kind of bank equipment and distance, character of material, kind of power equipment and its size, arrangement of factory, money available, and expenditure justified.

In figure 1 we have sketched a plant for making brick or tile to bring out again the independence as well as the relationship of the clay storage building with the rest of the factory. The car above the storage can discharge its contents at any place of storage or direct into the screw feeder for the factory. For using stored clay, the underground belt conveyor will be operated for charging the feeder mentioned. By means of movable boards above the conveyor duct, beginning from one end of storage, the material will slide down to the conveyor belt. This requires one man. This is not an expensive installation and will do well for a small or medium sized plant. It allows for extension by moving out the trestle.

A somewhat different system is illustrated in figure 2 where an elevator, receiving the raw or crushed material, delivers it through a chute either to the belt conveyor above storage or direct to the underground belt conveyor for direct use in the factory. The stored material can be dropped to the underground conveyor or be fed into the elevator at the factory at whatever height the storage level happens to be.

There are two modifications or improvements of this arrangement for the use of unstored clay, by either extending the underground belt conveyor to the left to receive the material direct without elevating it, or by extending the top belt conveyor to the right into the factory. Either scheme would eliminate one elevator for using unstored clay. These extensions are shown in dot and dash on the drawing.

Another method is shown in figure 3 where no conveying machinery is used and all transferring is done by cars. The

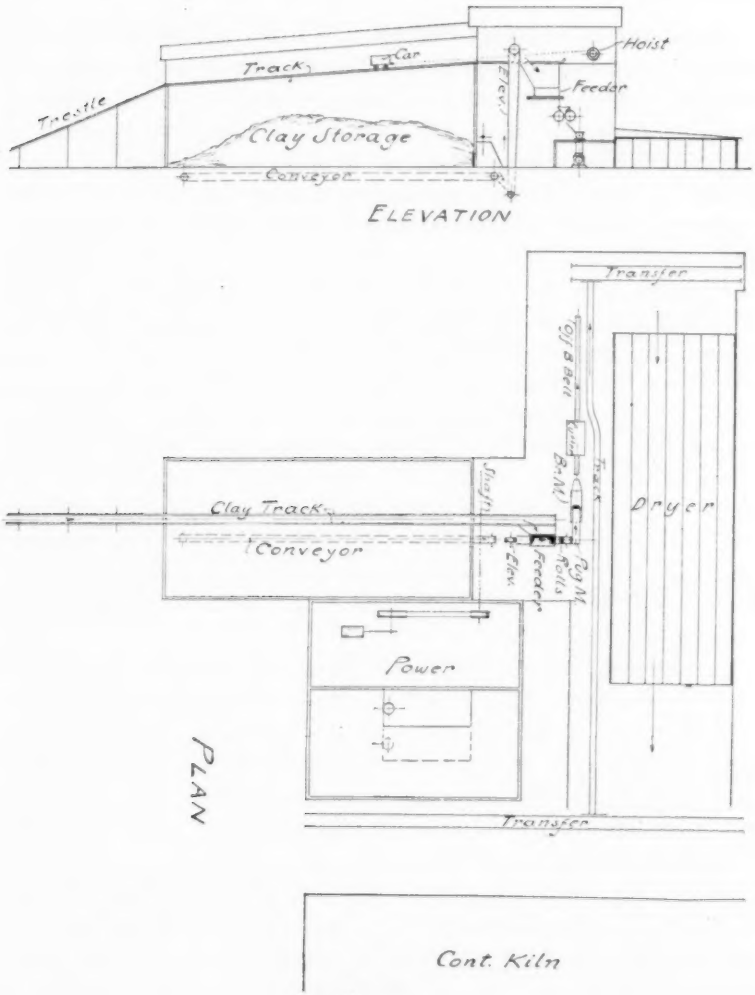


FIG 1

stored clay is taken or scraped down from storage pile and shoveled into cars, and these cars are then returned to the front of the

trestle to be pulled up by winding drum over the storage pile to the factory over the same track from which the clay is dumped into storage.

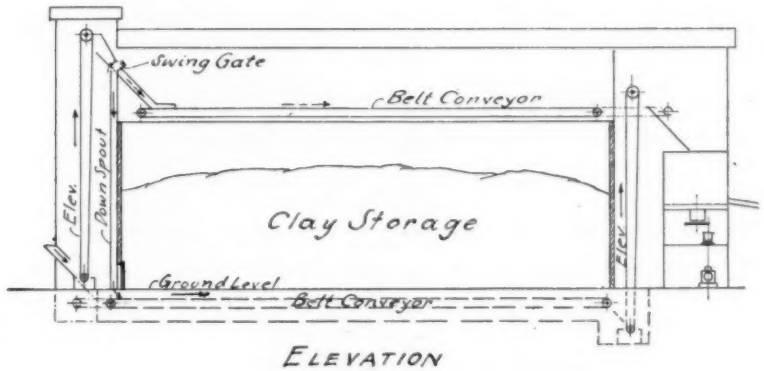


FIG. 2.

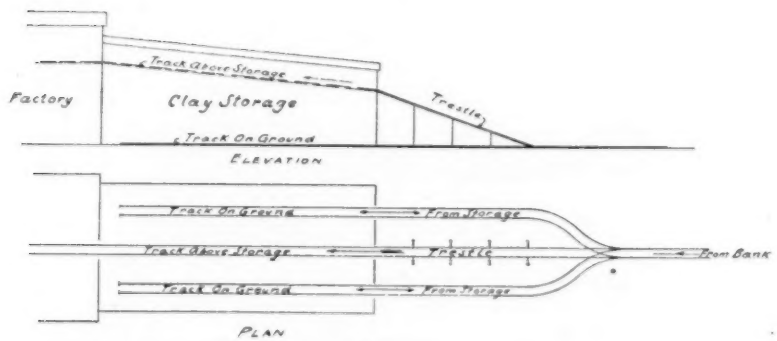


FIG. 3.

Figure 4 shows a somewhat different method for getting the clay from storage. The clay storage is divided into two piles at each side of the transfer track. The loading tracks are leading off to each side under the clay pile, and the clay is gradually worked down towards the end of each pile exposing more track as the emptying of storage proceeds. The inclined track to the factory is located to one side of the storage building and leads off from the transfer track.

In figures 5 and 6 we have two continuous systems for filling and emptying the storage. In the first system we have a continuous bucket conveyor or peck carrier, and in the second system

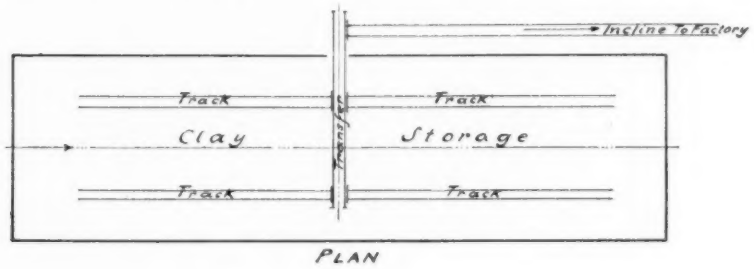


FIG. 4.

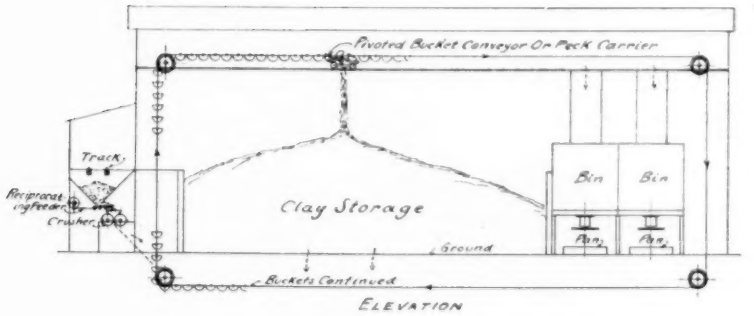


FIG. 5.

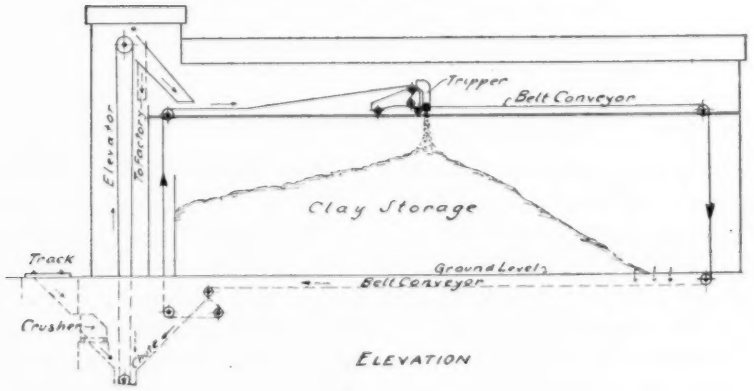


FIG. 6.

the trick is being done by means of a continuous belt conveyor. They allow for carrying the material to storage or to the grinding plant by one continuous conveyor, operated from one drive. These installations are more expensive than the previous ones and require more power, but they are undoubtedly flexible and can be used to advantage in plants of large capacity or with large storage.

The elevator in the belt conveyor system can deliver the material direct to the factory, being right angle to storage, by turning the spout 90 degrees. The stored clay is delivered to the elevator at the opposite side of elevator boot.

A tripper, as shown, running on rails, is perhaps the best way for discharging a belt conveyor at a desired place, even though a tripper will add to the cost of the installation. Sometimes a scraper is used above the belt. A scraper will not clean the belt completely and some material will remain on the belt to be discharged at the end. The rubbing effect of the material on the belt behind the scraper will result in quite some wear on the belt.

Sometimes a drag conveyor is used as shown in figure 7 and

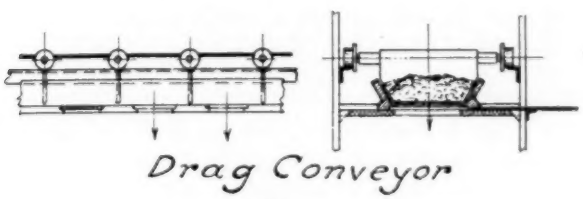


FIG. 7.

the clay is dumped through openings in the bottom or floor, and sliding gates are pulled out wherever the storage needs to be filled. Such a conveyor, single or continuous, can be used above and below storage.

Figure 8 represents a commendable system, initiated and fully described by Riddle in *Trans. Am. Ceram. Soc.*, Vol. XIX. The connecting link here between the dum pile and factory is a clamshell bucket attached to a crane. It allows piling at random with good mixing and can rightly claim flexibility.

In figure 9 we have a somewhat different system suggesting

round storage bins built of reinforced concrete or steel, being filled from a swivel spout of an elevator located in the center. Disc feeders at the bottom and one belt conveyor are to deliver

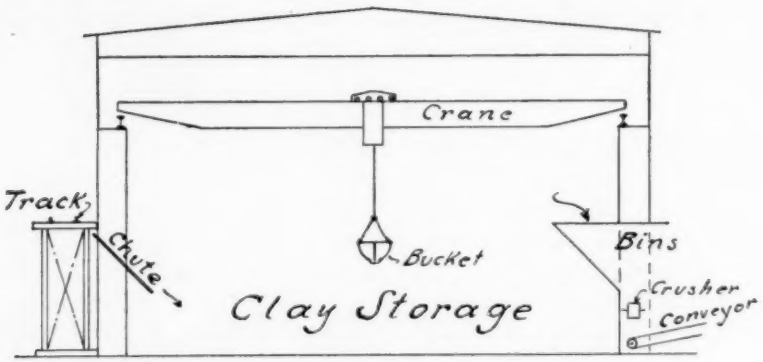


FIG. 8.

the stored clays to the factory. This system allows an excellent possibility for blending clays in proper and accurate proportions, and besides can be built within a small space. It can also be extended by adding more bins on the inside.

Returning Cars.—In order to return the car or cars from above storage, the track is sometimes sloped so that the cars including cable can return by gravity as shown in figure 3. Such a slope should be about one foot per 14 feet, or 7 per cent, but depends upon the conditions of the equipment.

Another way of returning cars automatically is to use a retriever as shown in figure 10. The extending loop near the upper end of the incline between rails is caught by a hook attached to the lower part of the car while being pulled up by the hoist. The car is pulled back by counterweights.

The counterweight shaft is connected with reducing gears to a cabledrum shaft which unwinds the cable attached to the car, pulling it back. The loop returns to its position between the rails when the car again passes this place on the upper incline on the return trip, the trip then being continued by gravity down

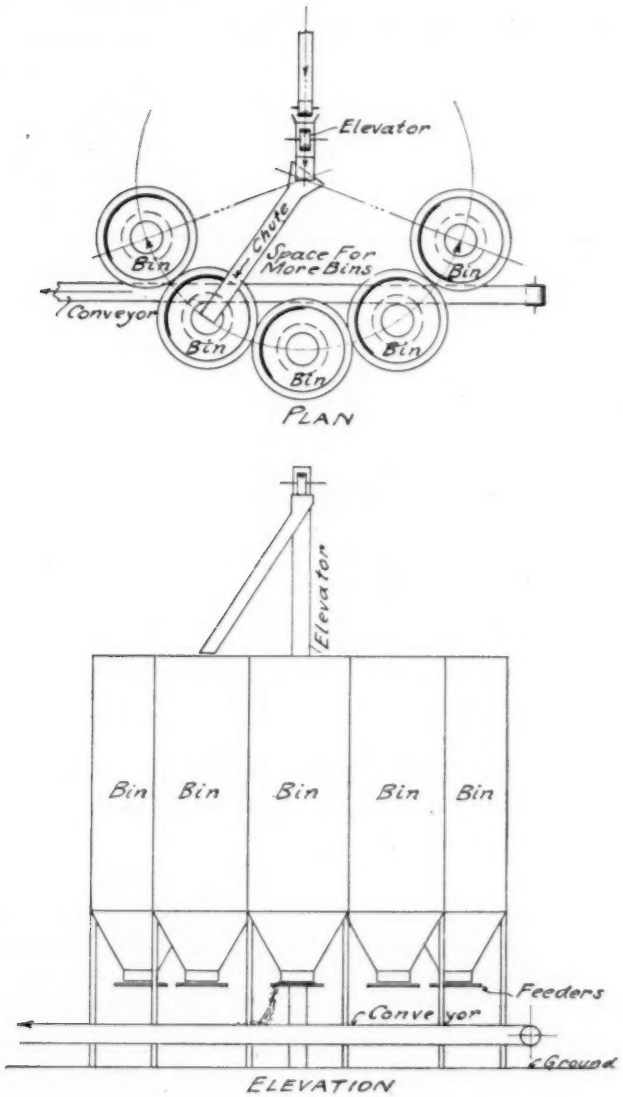

Elevator
Chute
Space For More Bins
Bin
Bin
Conveyor
Bin
Bin
Bin
PLAN
Elevator
Bin
Bin
Bin
Bin
Bin
Feeders
Conveyor
Ground
ELEVATION

FIG. 9.

the incline. Instead of using counterweights, a second winding drum may be used for pulling the car back.

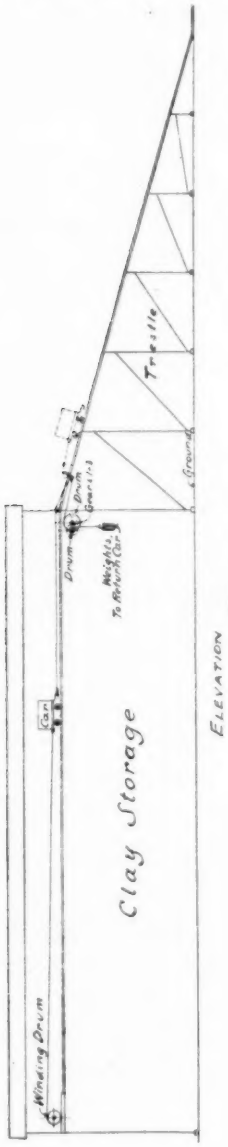


FIG. 10

Sheds and Buildings.—The details must be worked out in every case for every plant, and it is not the place here to go into an elaborate discussion of them, and besides a number of them comprise the standards of an architect or engineer; however, in order to properly appreciate our storage problems and to allow comparison, it is necessary to throw some light upon some details of construction.

Before a clay storage shed of proper proportions can be designed, the angle of repose for the material in question should first be determined by experiment.

In figure 11 we have a cross section through a clay storage shed

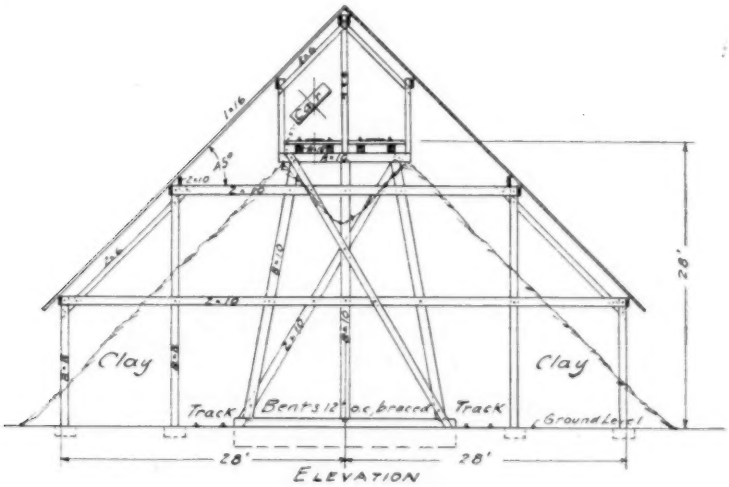


FIG. 11.

with a double track. It is put up of light timber and no rafters are used, instead the roof boards are placed at such an angle (at least 45 degrees), as to be self-supporting. It is a cheap construction, but has the disadvantage of much timber work within the clay pile with a tendency to breaking, due to unavoidable one-sided loading by clay. At the bottom the clay will roll out and form its own retaining wall. This shed requires about 7000 board feet of timber for 1000 tons storage capacity and is cheaper

than the other sheds mentioned later, mainly on account of the double track arrangement.

Figure 12 represents a single track shed of inexpensive and simple

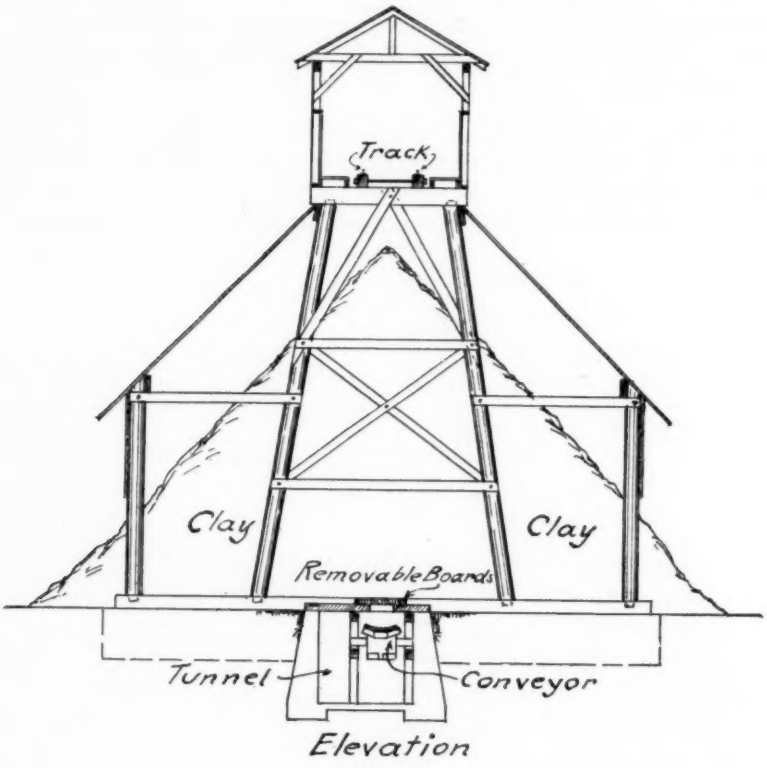


FIG. 12.

construction, well suitable for a small plant. The shed is, so to speak, built around the clay pile and little space is wasted. There are the self-supporting roof boards, but a heavier construction for the trestle.

For larger storage and where the angle of repose of the material is less steep, as, for instance, for coarse or perfectly dry material, a storage building as shown in figure 13 may be erected. The roof stringers are trussed, and they are resting on a concrete

retaining wall at one end and on the track cap at the other end. Such a wide building requires, for economic emptying, two underground tunnels with either conveyors or cars. To avoid the underground tunnels, the conveyor or car track can be placed above ground. This requires an overhead floor of heavy construction to carry the weight of the clay, but such buildings can be worked out and are in existence.

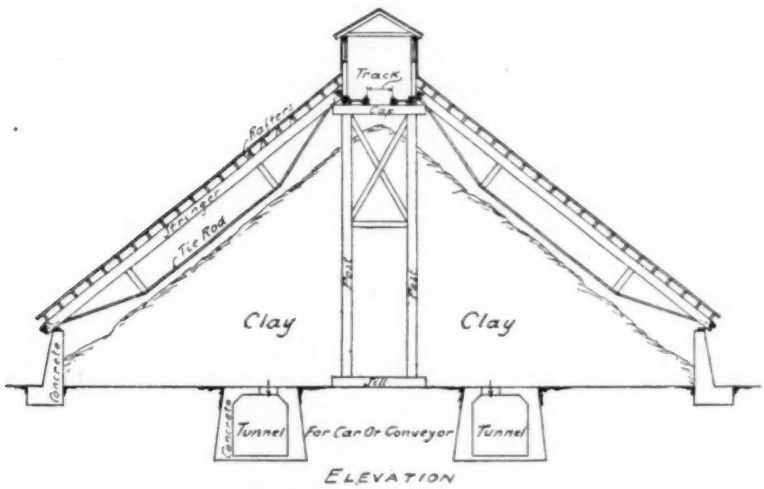


FIG. 13.

Where the clay storage building does not need to be very long, the grinding room or machinery building can simply be extended; and the clay track be placed within the roof truss. Such a construction is shown in figure 14. The truss may be built of steel, as shown, or of suitable timber and rods.

There is no question that buildings of a great variety of types can be designed and constructed, however, we can point out here but the most characteristic and most widely used types.

Retaining Walls.—The retaining wall is one of the most important elements in clay storage buildings, though we have shown cheaper types which did not have such walls. We can build such walls of timber, plain concrete, reinforced concrete,

steel, brick, or any combination of them. The following drawings of retaining walls are self-explanatory and hardly anything needs to be added.

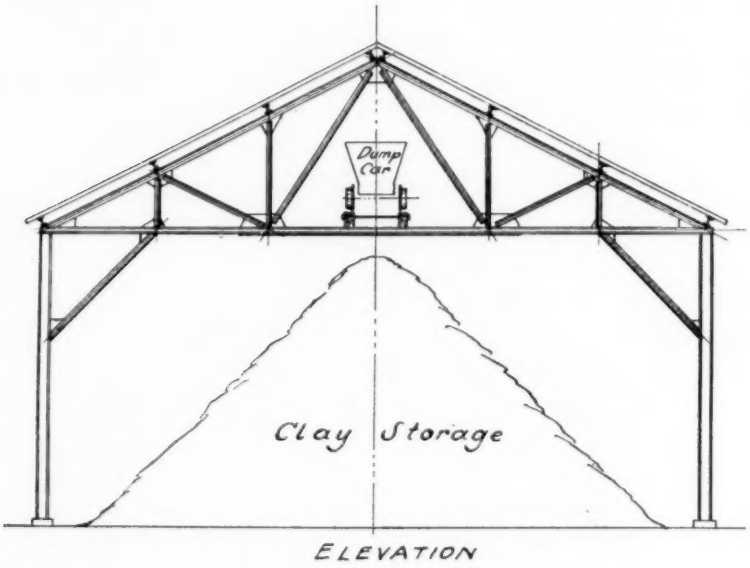
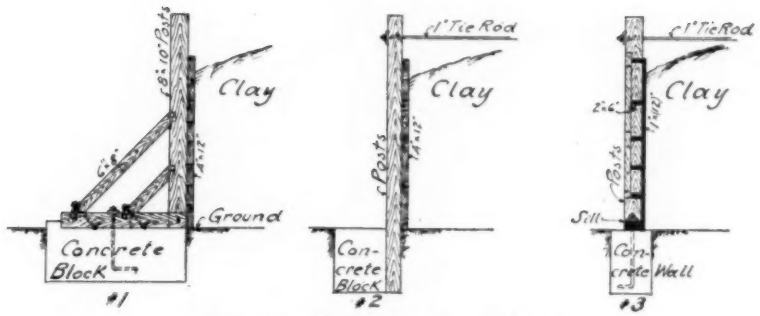


FIG. 14.

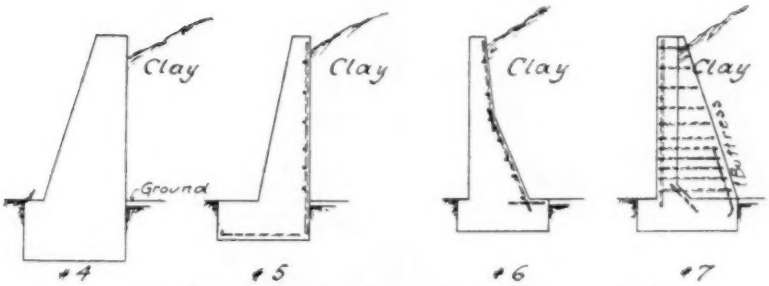
In figure 15 we have three representatives of frame retaining walls. In figure 16 we have plain concrete and reinforced concrete walls. This is not the place to go into a discussion of reinforced concrete design, which is a study by itself. We merely wish to mention that the steel bar reinforcements are placed where the wall is under tension. Figure 17 gives a retaining wall, using concrete, steel and timber. It is a strong construction and can be carried high. Figure 18 offers a suggestion for a wall built of steel and brick.

Retaining walls should be calculated to do the work and to be safe as the rest of the structure. While all these calculations are problems for the architect or engineer for the particular case, we wish to add a few words regarding the theory of retaining walls. There is a literature on retaining walls, and anyone interested can supply himself with much theoretical data.



FRAME RETAINING WALLS

FIG. 15.

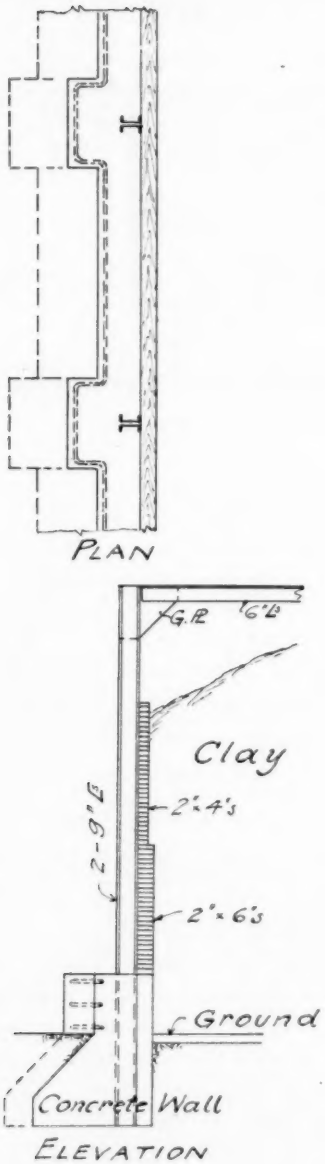


PLAIN AND REINFORCED CONCRETE RETAINING WALLS

FIG. 16.

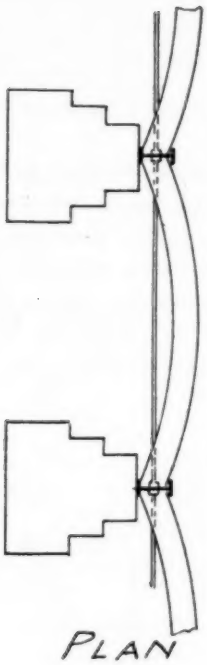
While there is a great variety of shapes of retaining walls for the many different purposes, we will assume that for the clay worker it dissolves itself into a wall with a straight and vertical back, a battered front, and a toe, as shown in figure 19.

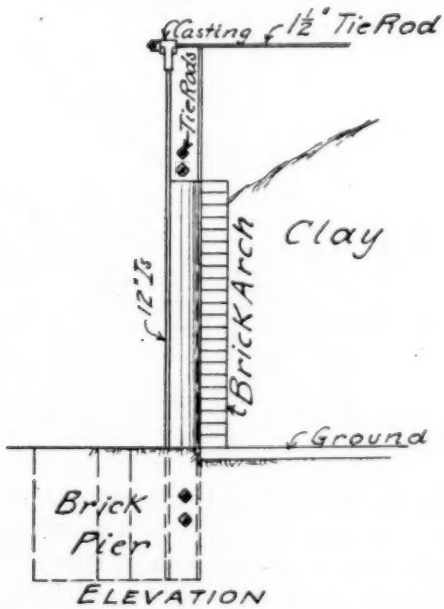
The wall must be strong enough in itself to prevent cracking or failure, it must be safe against overturning and safe against sliding. The clay behind the wall, tending to slide on itself and the surcharge, will tend to overturn it. The weight of the wall and footing or toe will be the resisting factors. The farther back we can keep the center of gravity of the wall the less it will tend to overturn. The soil pressure must be investigated, and if it is greater under the toe than the allowable unit pressure the base must be increased in area by extending the toe forward.



RETAINING WALL BUILT OF CONCRETE, STEEL, AND TIMBER

FIG. 17.





#9

RETAINING WALL BUILT OF STEEL AND BRICK

FIG. 18.

There are a number of theories on the design of retaining walls; but assumptions have to be made here, and many engineers are guided by practical experience rather than by theoretical considerations. However, all the earth pressure theories assume that the surface of rupture behind the wall is a plane, that the point of resultant pressure is at one-third the height of the wall from the bottom, and that the resultant makes a definite angle with the horizontal.

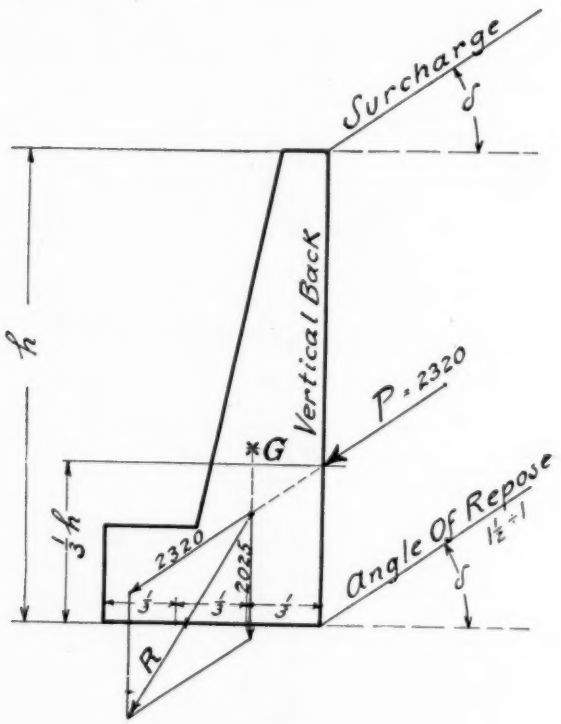


FIG 19

While there are, as mentioned, a number of theories, we wish to give here but a short and convenient method of checking the safety of a wall with a vertical back against overturning. The angles of repose and of the surcharge are assumed to be the same. The resultant earth pressure P then is parallel to these angles.

For this condition Rankine's formula receives the simple expression:

$$P = \frac{1}{2} w h^2 \cos \delta$$

where w is the weight of the filling per cubic foot
h is the vertical height of the wall in feet
δ is the angle of repose and surcharge.

In our case:

$$P = \frac{1}{2} \times 100 \times 7.5 \times 0.83$$
$$= 2320$$

This represents the resultant earth pressure behind the wall for the length of one foot.

The weight of the wall per foot figures 2025 pounds.

The resultant R of these two forces should fall within the middle third of the base, which we find to be the case.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

THE EFFECT OF THE METHOD OF PREPARATION ON THE VISCOSITY OF A CASTING SLIP

By V. S. Schory

Introductory

The properties of a casting slip are affected by a considerable number of variables. In developing a satisfactory composition for a casting slip it is necessary to take these variables into consideration and to improve the properties of a given casting slip by the selection of proper materials and by intelligent adjustment of the ingredients. The data necessary for this work can, of course, be obtained only by painstaking experiment. Having arrived at a composition which gives satisfactory results and which may be subjected to small variations without injurious consequences, the success of the casting process of manufacture is then largely dependent upon the elimination of variations as far as possible and upon their control by countering adjustments when they can not be eliminated.

When a casting slip is prepared from a ceramic body compound of feldspar, flint, china clay and ball clay the properties of the slip are dependent principally upon the following items: The ratio of the non-plastic ingredients to the plastic materials; the relative proportions of ball clays and china clays; the individual properties of each ball clay and china clay and the percentage of each clay used; the impurities naturally present in the clays and the foreign substances added to the clays in the process of preparation; the alkaline reagents used in the slip; the percentage of alkaline reagents—usually sodium carbonate and sodium silicate—used, and the ratio of the sodium carbonate to the sodium silicate; the percentage of water in the casting slip; the method by which the casting slip is prepared; the age of the slip; and its temperature.

The properties of a casting slip which it is desirable to maintain constant are: The specific gravity, the viscosity, the rate of casting, the firmness of the cast, the cleanness of drainage of

surplus slip from the cast, the strength retained by the cast, the hardening and drying of the cast in the mold and low shrinkage of the cast during the early stages of hardening and drying.

The viscosity of a casting slip is in itself of minor importance. The viscosity of a given slip may be varied by increasing or diminishing the percentage of alkaline reagents used or by varying its water content. As will be shown later, the viscosity depends also upon the method of preparing the casting slip. The more important desirable properties of a casting slip attain to their maximum development as a group at some definite degree of deflocculation as produced by the addition of suitable percentages of sodium carbonate and sodium silicate. This percentage of alkaline reagents may be increased or diminished only a small amount before unsatisfactory properties incident to excessive deflocculation or to insufficient deflocculation occur. For this reason it is not feasible to adjust the viscosity of a slip by changing the percentage of alkaline reagents used. However, a moderate variation in the water content may be used to regulate the viscosity of the slip and will have relatively little effect on its casting properties.

Having determined the percentages of sodium carbonate and sodium silicate which give a casting slip with the most satisfactory casting properties, the next step is to determine the minimum water content which at this degree of deflocculation will give the slip sufficiently low viscosity that it will flow through pipes of reasonable size and that the excess slip will drain cleanly from the cast in the mold. An increase in water content beyond that giving satisfactory fluidity for the operations of manufacture serves no good purpose; the excess water must be absorbed by the molds and in turn must be evaporated from the molds.

The most important properties of a casting slip do not lend themselves readily to rapid numerical measurement. The specific gravity is determined by weighing a given volume of the slip. The viscosity, or a numerical rating bearing a relation to the viscosity, can be satisfactorily determined by any one of a number of instruments, those of the flow type being commonly used. However, these two properties alone do not furnish much information concerning the action to be expected of the slip in

the mold. A slip may be prepared having any desired water content and viscosity and still be an utter failure when used in the casting shop. The rate of casting could be measured; but it is subject to a number of variables such as the character of the mold, the condition of the mold as regards water content and the number of times it has been used. The determination of the rate of casting also requires considerable time. The firmness of the cast is usually judged empirically by the feel of the cast in the mold. An instrument could be devised to measure this property, bearing in mind that a slip is unsatisfactory if the cast is soft or if it is hard, brittle and gritty when penetrated; that at the best the cast is firm but retains some plasticity and toughness. To make the determination accurate, the mold conditions would have to be standardized, as the character of the mold, its condition of moisture and the number of times it had been used would affect the results. This measurement also would be time consuming unless the determination could be made upon a thin cast, one formed in a few minutes. For the same reason it would be necessary to make the determination without removing the cast from the mold. The use of an instrument to measure firmness of cast has never come to the writer's attention. The clean-cut separation of surplus slip from the cast when a mold is drained is very important but is not readily measured. This property is usually satisfactory if the cast is firm. The strength of the cast, the rate at which it loses water and hardens in the mold and the shrinkage during this stage of stiffening are determinations requiring too much time to be used in the control of the casting slip.

Though the specific gravity and viscosity are not in themselves an index to the characteristics of a casting slip, they are useful means of factory control if the other factors influencing the properties of the slip are maintained constant. If the composition of the body does not vary and the water content of the slip is kept uniform, the viscosity becomes a measure of the degree of deflocculation of the slip and enables the operator to bring each charge of slip to a standard condition with sufficient accuracy to meet the conditions of factory operation.

In control work it is not necessary to determine the absolute

viscosity. The purpose is merely to duplicate results day after day. The quantity measured is ordinarily the time of flow of a given volume of slip through the outlet tube or orifice of a viscosimeter. The outlet may be an orifice, a short tube, a long tube, or a long tube contracted to an orifice at the end. In some cases the pressure head of the liquid varies as the instrument empties; in others the variation in pressure is largely counteracted by an immersed tube. One of the simplest viscosimeters is the Dudley viscosity pipette or an ordinary pipette of 100 cc. capacity or larger with the upper tube removed. The volume is read directly from the pipette. The Bureau of Standards type of viscosimeter for casting slips[1] has been repeatedly described and is a very satisfactory instrument. At their best casting condition a slight increase or decrease in the content of alkaline reagents produces a relatively great change in the viscosity of most casting slips, so that great accuracy in viscosimeter readings is not usually necessary. In a specific instance, increasing the alkaline reagents 3 per cent of their own weight reduced the viscosity reading 12 per cent.

Experimental

In the following study an attempt was made to hold all other factors constant while the method of preparation of the casting slip was varied. All the batches of body were weighed at one time from the same stocks of raw materials. After the body had been prepared by blunging, screening and filter-pressing, portions of it were made into casting slips by the different methods, using in each case the same proportions of body, water, sodium carbonate and sodium silicate. The time of flow of the casting slips was determined by the use of a viscosimeter of the Bureau of Standards type mentioned above. In the following the term viscosity refers to the relative time of flow of the given slip compared with water at 15° C. The instrument used delivered 200 cc. of water in 14.8 seconds. The time of flow of each slip was divided by 14.8 to obtain the quantity here designated as viscosity.

A body of the following composition was prepared:

[1] Bleininger, "Use of Sodium Salts in the Purification of Clays and in the Casting Process," Bureau of Standards, *Technologic Paper* **51**, p. 20.

35 Maine feldspar	6 Georgia china clay
20 Flint	8 Florida china clay
8 English china clay	8 English ball clay
10 North Carolina china clay	5 Kentucky No. 4 ball clay

This body is of a type commonly used for the production of vitreous earthenware and was designed to contain a number of variables. For this reason the clay content consists of English china clay, both residual and sedimentary domestic china clays and both English and domestic ball clays.

Casting slips were prepared from this body by twelve methods as given below. In methods 1 to 6, the slips were prepared by blunging in the usual double blunger. It is understood that in each case the blunger was running while being charged. In methods 7 to 12 the slips were prepared by grinding in a pebble mill. The sodium carbonate and sodium silicate were added in the form of 8 per cent solutions.

1. The water was charged into the blunger. Next the sodium carbonate and sodium silicate were added. The filter-press cakes were added to this.

2. To the water in the blunger was added the sodium carbonate. The filter-press cakes were charged into the blunger and the sodium silicate was added last.

3. To the water in the blunger were added one-half the filter-press cakes. The sodium carbonate and sodium silicate were added, and the remainder of the filter-press cakes charged into the blunger last.

4. To the water in the blunger were added one-half the filter-press cakes and then the sodium carbonate. Next the remainder of the filter-press cakes, followed by the sodium silicate.

5. To the water in the blunger was added the sodium silicate. The filter-press cakes were charged into the blunger and the sodium carbonate was added last.

6. To the water in the blunger were added one-half the filter-press cakes, then the sodium silicate, followed by the remainder of the filter-press cakes and then the sodium carbonate.

7. The water, filter-press cakes, sodium carbonate and sodium silicate were added to the pebble mill in order and ground 90 minutes.

8. The water, filter-press cakes and sodium carbonate were added to the pebble mill and ground 45 minutes. The sodium silicate was then added and the whole ground 45 minutes.

9. The water, filter-press cakes and sodium silicate were added to the pebble mill and ground 45 minutes. The sodium carbonate was then added and the whole ground 45 minutes.

10. The water, crushed dry filter-press cakes, sodium carbonate and sodium silicate were added to the pebble mill and ground 90 minutes.

11. The water, crushed dry filter-press cakes and sodium carbonate were added to the pebble mill and ground 45 minutes. The sodium silicate was then added and the whole ground 45 minutes.

12. The water, crushed dry filter-press cakes and sodium silicate were ground 45 minutes. The sodium carbonate was then added and the whole ground 45 minutes.

In preparing casting slips of the above body the amounts of anhydrous alkaline reagents used were: Sodium carbonate 0.027 per cent, and sodium silicate 0.036 per cent of the dry weight of the body. The specific gravity of the slips was 1.75, corresponding to a water content of approximately 30.5 per cent. The viscosity determinations were as follows:

Method of preparation	Viscosity	Method of preparation	Viscosity
1	5.21	7	4.68
2	2.72	8	3.64
3	4.77	9	5.09
4	3.07	10	10.3
5	4.60	11	4.18
6	3.78	12	8.3

An analysis of these figures brings out some points of interest. In methods 1 to 6 the casting slips were prepared by blunging. Of these the two having the highest viscosity were the slips to which both alkaline reagents were added at the same time, 1 and 3. The two slips ranking next in viscosity were those to which the sodium silicate was added early in the operation, while the sodium carbonate was the last ingredient added, 5 and 6. Those having the lowest viscosity were 2 and 4, to which the so-

dium carbonate was added at an early stage and the sodium silicate was added last. Of the casting slips prepared by grinding in a pebble mill three were prepared from filter-press cakes containing 21 per cent water and three from filter-press cakes that had been dried and crushed. In all cases the slips prepared from wet filter-press cakes were of lower viscosity than the slips prepared by corresponding processes, using dry clay. It is noted also that slips to which the sodium carbonate was added initially and the sodium silicate after a period of grinding were lower in viscosity than those to which the sodium silicate was added first and the sodium carbonate after a period of grinding. In the following table the members of the first column are the viscosities of slips to which the sodium carbonate was added early in the operation, while the sodium silicate was the last ingredient added. The corresponding members of the second column are the viscosities of slips prepared in the same manner except that the order in which the alkaline reagents were added is reversed.

2	2.72	5	4.60
4	3.07	6	3.78
8	3.64	9	5.07
11	4.18	12	8.3

A body used for casting heavy sanitary earthenware on a commercial scale was next used in preparing casting slips by the twelve methods cited above. In this case the specific gravity of the slips prepared by blunging was 1.75, while those prepared by grinding in a pebble mill were brought to a specific gravity of 1.72. It was noted in the first part of this work that slips prepared by grinding showed higher viscosity at their best casting condition than slips prepared similarly by blunging when the water content was the same in both cases. The reduction in the specific gravity of slips prepared by grinding was intended to bring both ground and blunged slips to approximately the same viscosity when they were at their best casting condition. The amounts of reagents added were 0.057 per cent sodium carbonate and 0.076 per cent sodium silicate in terms of the dry weight of the body. The viscosity determinations were as follows:

Method of preparation	Viscosity	Method of preparation	Viscosity
1	6.26	7	3.82
2	2.95	8	2.61
3	5.82	9	4.18
4	3.50	10	8.3
5	5.07	11	3.61
6	4.45	12	8.8

In general these figures confirm the results obtained by the use of the special body given above. Of the slips prepared by blunging 2 and 4 had the lowest viscosity. Five and 6 ranked next, and 1 and 3 were the most viscous. As before, the slips prepared by grinding wet filter-press cakes showed lower viscosity than those prepared by grinding dry clay. It is also noted that casting slips to which the sodium carbonate was added first and the sodium silicate later gave lower readings than the corresponding slips to which the sodium silicate was added first and the sodium carbonate later. In comparing the viscosity of the slips prepared by grinding the special body with that of the slips prepared by grinding the commercial body it must be borne in mind that in the latter case the viscosity was reduced by an increase in the water content.

The next part of the work consisted of preparing casting slips from the commercial body by the twelve methods given above and at the same time so adjusting the percentages of alkaline reagents used that all the slips had approximately the same viscosity. The specific gravity of the blunged slips was 1.75; of the slips prepared by grinding, 1.72. The viscosity of each slip was between the limits 3.65 and 3.35. The following table gives the percentages of reagents used.

Method of preparation	Sodium carbonate per cent	Sodium silicate per cent
1	0.0745	0.099
2	.0545	.0725
3	.0645	.086
4	.0570	.076
5	.0645	.086
6	.0620	.083
7	.0585	.078
8	.0465	.062
9	.0595	.079
10	.0855	.114
11	.057	.076
12	.0805	.1075

These slips were cast in plaster molds to determine whether the same body composition always gave the same result when the slip was brought to its best casting condition or whether the method of preparation influenced the casting properties of slips brought to the same viscosity. A study of the casts disclosed considerable variation in properties. The firmness of the casts was judged by the feel of the casts in the molds after the slips had been casting for 10 minutes. The slips were allowed to cast for 30 minutes when the fluid slip was drained from the casts and the comparisons made again after the casts had hardened for 10 minutes. In this way the slips were classified into the following groups: Firm cast, 2 and 4; reasonably firm cast, 1, 3, 5, 6, 8 and 9; fair, 7, 11 and 12; rather soft, 10. This method of measuring firmness does not permit of great accuracy so no comparison was made between members of the same group. Of the slips prepared by blunging those with the lowest content of alkaline reagents gave the firmest casts; the methods of preparation requiring greater amounts of sodium salts to bring the slips to their best casting condition gave slips which did not cast so firm. With reference to slips prepared by grinding this relation did not hold rigidly though method 10, requiring the greatest addition of alkaline reagents, gave the softest cast.

Discussion of Results

In general, firmness of cast is a very desirable property in the casting process and this fact recommends certain methods of preparation above others. Other factors may, however, modify the choice. For example, if the cast has the property of hardening rapidly in the mold after draining this property may overcome the effects of the softness and flabbiness of the original cast. The writer has observed a casting slip used in the manufacture of sanitary earthenware which gave a soft and apparently inferior cast at first but after draining the cast hardened rapidly in the mold and gave very satisfactory results.

Aside from the fact that blunged slips with the lowest content of alkaline reagents gave the firmest casts, another important consideration would recommend these methods of slip preparation in certain cases. In casting heavy ware using a slip that

requires a considerable addition of sodium salts to bring it to its best casting condition it sometimes happens that the high content of soluble material in the slip has a number of annoying effects. The water absorbed by the mold carries sodium salts in solution; when the water is evaporated from the mold the soluble salts are deposited as a frost-like growth or they may form a shell on the face or back of the mold. After a time this surface shell becomes comparatively impervious and hinders subsequent absorption by the mold and evaporation of water from the mold. Sodium salts are in solution also in the water remaining in the ware, when it is removed from the mold. As the piece dries these salts separate out near the surface of the ware and often appear as a brownish scurf, especially noticeable at sharp corners and edges where the evaporation is greatest. The concentration of alkali near the surface renders that portion more fusible than the body of the ware, and when the ware is fired surface vitrification results. In dipping the ware the glaze may not adhere satisfactorily to this glossy surface. In extreme cases the surface is so fusible that blistering occurs in the biscuit fire. The extent to which these undesirable conditions occur depends principally on the concentration of soluble salts in the casting slip; and if by changing the method of preparing the slip the content of alkaline reagents can be reduced, a simple solution is offered to the problem of eliminating or diminishing these difficulties of the casting process.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

A PRACTICAL TEST FOR THE RESISTANCE OF OPTICAL GLASS TO WEATHERING[1]

By F. R. v. Bichowsky

Early in the campaign to increase the production and improve the quality of the optical glass needed for war purposes, doubts were felt as to the stability toward weather of certain of the glasses developed.

Previous to the summer of 1917, when the Geophysical Laboratory began its optical glass work, there appears to have been no attempt made by the manufacturers of optical glass in the United States to test the weather stability of their glasses. They were content to assume that the glasses, modeled after European formulas, would be at least as satisfactory in their resistance to weather as their European counterparts. The Frankford Arsenal, however, had for several years made tests for weather resistance on the glass submitted for military purposes. Three methods were developed there. In the first the glass was spotted with a 1 per cent solution of acetic acid which was allowed to evaporate in place. This test, which is said to give effects "similar to the effect of perspiration," apparently is not very sensitive, as "reddish blue spots" and "faint corrosion of the edges" were recorded for only one glass, Crown No. 1, 605, Melt 5772. Tests 2 and 3 consisted in the exposure of the glasses to 1 per cent acetic acid and 1 per cent glucose solutions for varying lengths of time. These tests, which are said to be "similar in effect to perspiration" and "to exposure to a warm climate such as the Philippines," give somewhat ambiguous results, at least in my experience. Moreover, they take too much time for routine factory testing.

It was, therefore, desired to extend and supplement these tests by a series of practical tests which could be carried out easily and quickly by the work's chemist, which would not depend too

[1] Presented before the Glass Division of the American Ceramic Society, February 24, 1920.

much on the judgment of the worker, and which would be varied enough to give some assurance that no essential peculiarity in the stability of the glass towards varying climatic conditions could be overlooked.

The ideal thing, of course, would have been to expose a carefully graded series of glasses to different and well-controlled climatic conditions for long periods of time, following somewhat the procedure of Zschimmer.[1] This was entirely out of the question in our case, since our need was for immediate data for war purposes. It must be remarked, though, that any ultimate correlation made between the results of artificial tests for the corrosion of glass by different reagents (such as those given below) and the actual weather resistance of the glass to real climatic conditions must depend on some such investigation. All that could be done here was to pick out tests sufficiently varied so that it could be reasonably hoped that whatever might be the peculiar susceptibilities to weathering of the glasses in question, they would be detected by some of the tests employed.

Optical glass is not readily obtained in the form of blown articles, nor can it be blown readily in the laboratory. It was thus impracticable to test the glasses by the methods used to test the stability of chemical glass.[2] The optical glass tested usually came in the form of pressed or polished plates from 1 to 2 cm. thick, these often being samples which had been discarded in the factory inspection on account of fine striae. As would be expected, experiment shows no marked effect on the weathering quality of the glass due to fine and almost imperceptible striae present in the optical glass tested.[3]

The first test that suggested itself was the well-known "surface alkali" test described by Mylius.[4] This test depends on the

[1] E. Zschimmer, *Chem. Zeitg.*, **25**, 730–732 (1901).

[2] Such, for example, as those used by Walker and Smither, *Jour. Ind. Eng. Chem.*, **9**, 1090–1092 (1917).

[3] Blown ware often shows marked differences of resistance to "weathering" by hot water, at least along the combined striae and molding lines of the article. (See the following paper.) But these "striae" are of a very different magnitude from those found in optical glass.

[4] F. Mylius, *Z. anorg. Chem.*, **55**, 233–260 (1907); **67**, 200–224 (1910); *Silikat-Zeitschrift*, **1**, 2–5, 25–28, 45–48 (1913).

fact that when a freshly broken surface of glass is placed for a given period in a dilute ether solution of iodeosin, $C_{20}H_8I_4O_5$, a certain amount of the ether-insoluble alkali salt of this acid, depending, among other things, on the alkalinity of the glass, is precipitated on this surface. The excess free iodeosin can easily be washed off with a little ether, and the amount of iodeosin in the form of its alkali salt can be found by washing off the surface with a little water, in which the alkali salt is soluble, and determining colorimetrically the total amount of indication in this extract. The details of the procedure differ but little from those given by Mylius. The following solutions are needed:

Solution A.—0.53 gram of sodium iodeosin, *i. e.*, erythrosin B or anilin red (caution: several different dye-stuffs are sold in the United States under these trade names) is dissolved in a 2-liter separatory funnel in 30 cc. of H_2O. To this solution is added 15 cc. of a one-tenth normal solution of sulfuric acid. The free iodeosin will be precipitated by this procedure in large orange-red flakes. The mixture is then shaken vigorously with a liter of well-washed ether until the free iodeosin is entirely dissolved. (The acid must be added before the ether, otherwise it is difficult to make the dye-stuff dissolve.) The aqueous layer is removed and the ether solution washed three times with a little water (about 30 cc.). The water from the last washing must be distinctly red.

Solution B.—Solution A is sensitive to light and slowly becomes acid through oxidation. To maintain the solution as sensitive as possible it is kept in a stoppered bottle of brown glass, in contact with 30 cc. or so of a 1 per cent solution of sodium iodeosin. This bottle must be kept full (to keep out air) by adding more of solution A every time solution B is used. Mylius recommends keeping some fragments of soda glass or some glass beads in the bottle to prevent the solution becoming acid, but with ordinary American glass bottles this is unnecessary.

Solution D.—0.01053 gram of pure sodium iodeosin is dissolved in a liter of water. This solution, which should be kept in the dark, contains 0.01 mg. of free iodeosin per cc., and is used as a

standard solution. It is comparatively stable and can be kept for several months in a dark bottle without change.

Besides these solutions, neutral water saturated with ether will be needed. Ether of the grade used for anesthesia, which has been washed a couple of times with fresh distilled water, will serve.

The procedure recommended is as follows: The plates of optical glass are washed with ether, alcohol and water, and dried on a soft cloth. They are then scratched with a diamond so as to give, when cut, several square centimeters of fresh surface. A little of solution B is placed in a shallow dish so as to make a pool half a centimeter deep. The plate of glass is then broken along the diamond scratch with a quick light tap of a wedge-shaped hammer, the glass being held scratched side down in the palm of the hand or supported between two pieces of cork. The freshly broken surface is then put face down in the ether solution and gently moved around for one minute. The pieces are then quickly removed, rinsed with the prepared ether and allowed to dry. The excess indicator on the old surfaces of the glass and in the neighborhood of any imperfections on the new surfaces is carefully removed with a damp cloth, pains being taken that no water gets on the new surface and that no dye is left on the old surface and especially on the rough edge where the diamond has cut. The dye on the fresh surface is then carefully washed with a few cubic centimeters of water into one of two similar small deep beakers. The color is compared with that of the standard solution D by adding solution D drop by drop from a graduated burette into the other of the two beakers until a perfect match is obtained, taking the usual precautions, as to light and volume of solution, needed in all colorimetric work. The other dyed surface of optical glass should be treated in a similar manner, the two beakers being interchanged, however. The amount of solution needed for the color should be nearly the same, and the mean value should be taken. This value, in cubic centimeters of solution D used, multiplied by 100 and divided by the estimated area of the fracture in square centimeters, gives the number of milligrams of adsorbed iodeosin per square meter. This value may be called the surface alkalinity constant of the glass in ques-

tion. As Mylius has shown, glasses can be fairly grouped into five classes on the basis of this constant, namely:

		Mg. per sq. m.	Example
Class I.....	Totally insoluble glasses	0– 5	"Quartz glass" (fused silica)
Class II.....	Resistance glass	5–10	Jena Geräte (chemical) Pyrex
Class III.....	Hard glass	10–20	Flints, best crowns
Class IV.....	Soft glass	20–40	Ordinary crowns
Class V.....	Poor glasses	over 40	

Optical glasses should all have a surface alkalinity less than 40, though it is to be noted that glasses high in lead (such as the extreme microscope flints) give high values for surface alkali[1] while they are extremely insoluble in water. This is possibly due to the formation of a lead salt of iodeosin in place of the alkali salt formed on ordinary glasses. It should also be noted that certain glasses containing barium and possibly zinc, though they give low surface alkali values, have very high solubility in acid, and are presumably only fairly stable to weather. For these reasons the results of the surface alkali test should always be interpreted in conjunction with other tests.

The further test given by Mylius, namely, the amount of indicator absorbed on glass surfaces which have been exposed to water vapor at 18 degrees for seven days, is somewhat inconvenient and uncertain, and it was felt that it was too similar in principle to the first test to have especial value.

It was at first hoped that some convenient quantitative method could be found for determining the true rate of solubility of glass in water and various other reagents. Conductivity and electromotive force methods were tried but were thought to be too difficult for routine work. Extraction of a known surface of glass with concentrated ammonia, 1 : 1 hydrochloric acid, and water, filtering, evaporating to dryness, and weighing the extracted alkali, was tried with fair success on nearly all the glasses employed. The glass used was cut up into small cubes, and their surface was estimated; they were then extracted for 48 hours on a

[1] Hovestadt, "Jena Glass," (transl. by J. D. and A. Everett), p. 323. London, 1902.

water bath, using fused silica or silver beakers. The extract was then concentrated to small volume, filtered, and evaporated to dryness in small platinum dishes. Filtration is necessary as the glass spalls badly, and it is difficult to separate the undissolved splinters of glass from the slush of hydrated silica which settles to the bottom of the beaker. This spalling also makes the estimation of total surface very uncertain, and the more or less colloidal state of the silica renders uncertain whether the filtered solution represents fairly the amount of alkali dissolved, or whether it represents in addition more or less of the silica. This last source of error can be overcome, of course, by acidifying the extract with HCl before evaporating to dryness, and carrying out the usual procedure for the elimination of silica. The whole method, however, is thought to be not satisfactory for routine use.

The tests finally adopted are not quantitative, and their interpretation depends somewhat on the judgment of the operator. They are, however, simple and rapid, and a little practice will make interpretation quite positive enough for the purpose. The tests consist in heating the glass to high temperatures with various solutions and noting the appearance of the surfaces, both when wet and when dry. A great many types of solutions were tried, but water, 5 per cent solution of sodium hydroxide, and 1 : 1 hydrochloric acid prove to give the most satisfactory results, and apparently nothing is to be gained by extending this list.

Steel bombs were used for the extraction with water and sodium hydroxide. The fragments of glass, half-inch cubes, which may be weighed, marked and described for identification, were introduced. The bomb was filled three-fourths full with the solution used, put quickly into a furnace kept at approximately 225° C., and left there for 4 hours, in the case of water, and 2 hours in the case of 5 per cent sodium hydroxide solution. A standard sample of glass was always used in each bomb. It makes very little difference what the standard sample is. I used Jena thermometer glass 59^{III}. The test with 1 : 1 hydrochloric acid was made in sealed tubes of Jena combustion glass at a temperature of 175° C. for 6 hours.

The appearance of different glasses under these tests can be

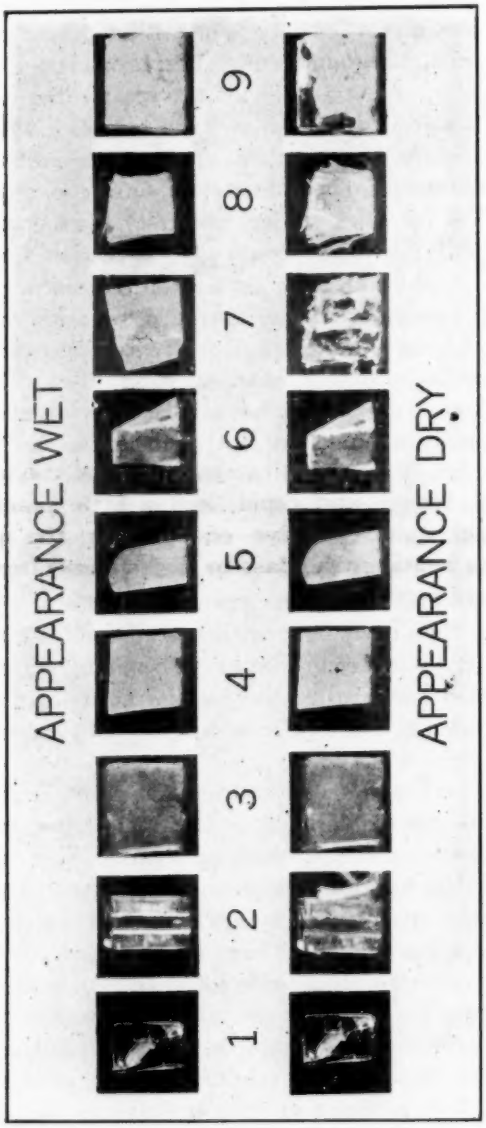


FIG. 1.

judged somewhat from the photographs in figure 1. Under these conditions glasses can be graded rather sharply as follows:

Grade	Appearance wet	Appearance dry
9	Thick slushy film	Film more than 1.5 mm. (1/16 inch) thick when dry
8	Thick film	Flakes off when dry
7	Deep etching in scratches and corners	Thin film, flakes off when dry
6	Deep etching in scratches and corners	Thin film, does not flake off when dry
5	Opalescent film	Deeply etched
4	Opalescent film	Not etched
3	Film	Film
2	Clear	Film
1	Clear	Clear

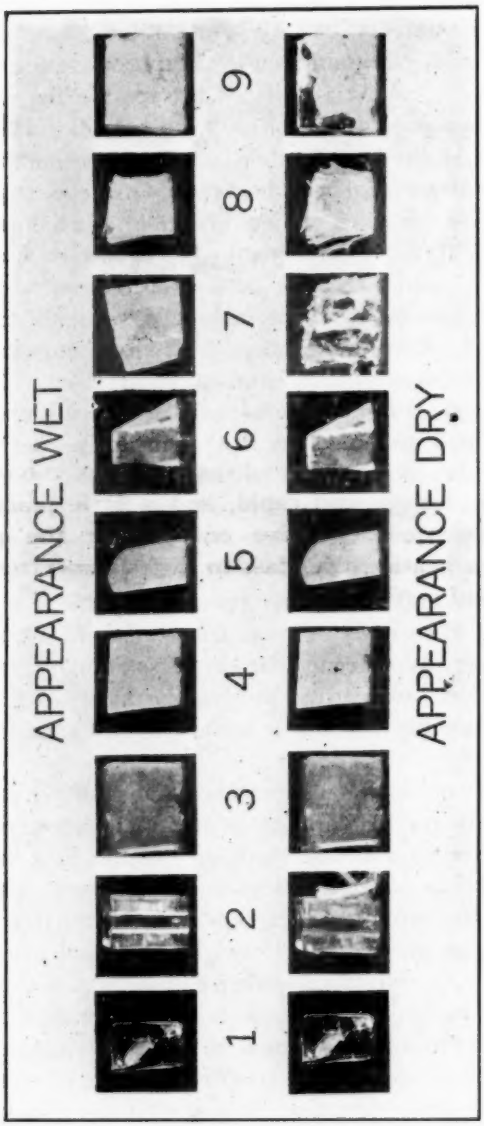
It is also possible to keep track of the loss of weight, but with glass samples which have sharp edges the loss due to spalling and chipping renders these results less positive than the appearance of the test pieces. Typical results obtained by these tests are given in table 1. Column 1 gives the glass tested, column 2

TABLE 1.—RESULTS OF WEATHERING TESTS ON OPTICAL GLASSES BY VARIOUS METHODS

Glass	Surface alkali	Solubility in water. Mg.	Grade by appearance		
			H_2O	NaOH	HCl
BL. 100	44	130	6	7	2
BL. 500	15	57	5	8	3
BL. 3000	13	39	4	3	1
BL. 3700	16	(170)? 54	1	2	1
BL. 700	25	70	2	4	9
PPG. *A*	24	(420)?	2	8	1
PPG. *C*	33	86	4	2	2
PPG. *E*	50	140	5	9	3
PPG. *H*	18	51	3	5	1
Microscope flint	39	..	1	2	1

the results for the surface alkali test, column 3 loss of weight of centimeter cube in distilled water in milligrams per test, and columns 4, 5 and 6 the grade in accordance with appearance.

It will be noted that there is considerable difference in the order of stability that would be assigned according to the different



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the results for the surface alkali test, column 3 loss of weight of centimeter cube in distilled water in milligrams per test, and columns 4, 5 and 6 the grade in accordance with appearance.

It will be noted that there is considerable difference in the order of stability that would be assigned according to the different

tests. Thus glass BL. 700 is actually so soluble in hydrochloric acid that crystals of $BaCl_2$ separated out of the acid in 6 hours heating. This glass loses one-tenth of its weight in boiling 1 : 1 hydrochloric acid in 72 hours. On the other hand, according to all other tests, it is a fairly good glass. Just what the weather resistance of such a glass would be it is hard to say. However, it is certain that if we depended on any single one of these tests alone, our estimate of the probable weather resistance of the glass, though more *definite* than the result of the group of tests taken together, would very likely be wrong. Probably the safest thing to say is that glasses such as BL. 100 and PPG. *E*, which are poor according to *all* tests, are likely to have poor weather resistance, and those that are satisfactory according to all tests are likely to be satisfactory under actual weather conditions. Glasses which are intermediate in quality or show great variation under the different tests should be considered with suspicion and means should be taken to obtain field data as to their actual weathering stability. With such a body of data, no doubt, correlation factors could be obtained between the results of the artificial tests and actual weathering resistance.

GEOPHYSICAL LABORATORY
CARNEGIE INSTITUTION OF WASHINGTON
July, 1919

DISCUSSION

MR. GEORGE W. MOREY.—We should be very cautious in giving weight to stability tests made under such extreme temperature conditions as 225° C., and with such violent reagents as 1 : 1 HCl and 5 per cent NaOH. While the results of such tests are interesting, it is up to those presenting such tests to the manufacturer to show that they have some bearing on the actual behavior of the glasses under the conditions of use BL. 700, a glass which has shown itself, in actual use, to be fairly resistant, appears decidedly inferior when treated with 1 : 1 HCl at 225° C.; not very surprising when we consider the conditions of the experiment.

The phenomenon is one of rate of decomposition. Superimposed on the purely accelerating effect of temperature we undoubtedly have other effects which profoundly affect the rate,

and hence the magnitude, of the effect we measure. The only silicate systems whose actual equilibrium relations with water are known, the alkali silicates, show a profound difference in behavior at 200° and at room temperature; not only differences in equilibrium relations but also in the condition of the products of decomposition, whether passing into true solution or into an unstable peptized state or even remaining as translucent to transparent layers, apparently unaltered in appearance, but with alkali or other dispersed material replaced by water. Similar effects were observed by Van Bemmelen with SiO_2 gels, and by the author with alkali silicate crystals.

To be of real value in factory control, the method must be competent not merely to show the difference between a borosilicate crown and a barium flint, but furthermore to show the effect of changes in batch composition in the case of a given glass. If a certain glass is not as stable as it should be, and we change the Na_2O : K_2O ratio, or add alumina, have we made a step in the right direction? The manufacturer wants a method which will answer these practical questions, and answer them in an unequivocal manner. If the method takes a week to carry out, instead of an hour, all right, as long as it gives results.

It has always been customary to use a freshly broken surface for weathering tests; this is proper. But the surfaces with which we are really concerned are always polished surfaces; an investigation of the effect of polishing on weathering is desirable. If there is the marked difference in properties between the polished surface and the interior, inferred by French from his experiments on polish; if the properties of the β-layer are so markedly different from those of the α-layer in other ways, it would surely differ greatly inweathering. On the other hand if thead vocates of the chemical theory of polishing are correct, in this case also the polished surface should differ from the interior, and, moreover, surfaces equally polished should be different when different polishing mediums are used. These questions need investigation.

SPENCER LENS CO.
OPTICAL GLASS PLANT
HAMBURG, N. Y.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

MR. W. F. BROWN.—Dr. Bichowsky's work to develop simple and rapid tests for grading optical glass as regards its ability to resist weathering calls to mind a problem once submitted to the writer by a manufacturer of glass other than optical. It was required to give within as short a time as possible a report as to which of several glasses would best resist weathering action while in the warehouse, the ware being packed with hay or straw in wood boxes.[1]

Chemical weathering tests described in the literature were decided not to be positive enough to apply directly to the case in question, but they indicated what course to follow with only a partially equipped laboratory and no autoclave available. It was desirable to have test pieces large enough to show why the particular glass recommended was more resistant than the others.

It is generally known that the reason glass deteriorates in storage is because it "sweats." Even in a dry warehouse, temperature and humidity changes cause closely packed glass to become damp or even wet. Ordinary soda glasses "bloom" after a short storage period, and under more severe conditions and longer storage the glass surface may become so iridescent or etched that its deterioration affects quality appreciably. When too badly "bloomed," ordinary methods of washing will not restore the surface.

A little experimenting showed that in every case the "sweat" from packed glass was alkaline, the alkalinity apparently increasing in direct proportion to depth of surface corrosion. Following results to be expected from the usual methods for testing stability of chemical glassware, it was noticed that a glass surface given an artificial alkalinity, as by dipping into a dilute solution of sodium hydroxide, and kept dry, would not alter its appearance, while the same glass so tested and put where it would "sweat" showed signs of surface deterioration within a week.

A number of boxes representative of the several glasses to be

[1]No attempt has been made in this discussion to give references, and it is realized that a much better method for determining tests was published in the August, 1919 number of the *Journal Society of Glass Technology*. The particular work, however, to which I had reference was done quite a while before the above article appeared.

tested were then taken directly after manufacture and packing, and buried in fresh horse manure, not exposed to outdoor weather. The pile had been well mixed, and care was taken to have each box surrounded with about equally thick layers of dung. The pile was sprinkled with water every few days, but was at no time wet enough to make wet the boxes or hay packing. All the moisture which collected on the glass was due to "sweating." Temperature within the pile at first was 118° F. and gradually diminished to 95° F. within 30 days. At the end of the 30 days, when some of the glass was taken out of pack, it was easily seen which glass was most resistant to weathering action, at least under actual storage conditions.

An analysis of the glass tested led to the belief that it was much more stable than ordinary bottle glass, but not so stable as good chemical ware.

It may be asked if the humus gases aided surface corrosion. It is not believed they caused any effect. A number of pieces of glass were put into a water-jacketed copper oven kept at 180° F., and into which were passed streams of carbon dioxide and ammonia. It was difficult to control the humidity of the oven atmosphere, and in the rough experiments so conducted the glass could not be made to "sweat" as it did in the manure pile, and no definite results were obtained from the few oven tests made.

From the comparative results obtained by burying packed glass in manure, which method in reality gave a crude combined thermostat and humidostat, it is suggested that if work be done as proposed by Dr. Bichowsky to compare actual long-period weather resistance of glass with results produced by his practical laboratory tests, it would be interesting to correlate further the relation between artificial "sweating" for short periods under known and reproducible conditions with the actual long period weathering.

MR. A. J. WALCOTT.—In connection with the "weathering" action of glass, especially optical glass, the writer has been especially interested, not only in the causes but also in determining the nature and composition of the resulting deposit. It has already been reported by a number of investigators that the

result of one form of weathering is a deposit of small globules and a pitted condition of the surface. A careful microscopic study of a large number of specimens of glass, subjected to weathering action, has brought the following information:

Each pit is filled with a globule or bead of a stiff jelly-like substance, soluble in water. The substance has been found to possess the property of double refraction, giving an interference color of low order. In a few cases a faint biaxial interference figure has been observed. The index of refraction has as yet not been determined but has been found to be lower than 1.6. Flame tests and blowpipe tests have led the writer to believe that, in at least some cases, the composition of these "beads" is potassium silicate.[1]

Further experimental work seems well worth while and will undoubtedly lead to interesting and valuable information.

[1]This work was done at the Bausch & Lomb Optical Co., and with glass having an index of refraction of 1.616.

NOTE ON THE MECHANICS OF THE "WEATHERING" OF GLASS[1]

By F. R. v. Bichowsky

It has been noted by a number of workers[2] that water is taken up in considerable amount by fresh glass surfaces. Thus glass which has been soaked in water for some time will lose considerable weight on drying to 150°. Schott notes, for instance, a glass which had adsorbed as much as 10.7 milligrams of water per square decimeter of surface. Apparently the mechanism of this ad- or absorption differs with different kinds of glasses, but in general it seems to consist of the following stages:

1. True adsorption of water on the surface.

2. Diffusion or "solution" of the adsorbed water molecules into the body of the glass.

3. Reaction of the dissolved and adsorbed water with the glass, forming a surface film of more or less thickness and of a character depending on the composition of the glass.

4. Soaking up by this film of considerable amounts of water with consequent further reaction.

5. Extraction of the soluble salts (mostly the alkaline carbonates and hydroxides) from this surface film.

6. Solution of the silica skeleton film in the strongly alkaline solution formed.

Of course, these changes are not absolutely definite. There is a certain amount of overlapping. Still it is assumed they are approximately definite.

Now, if a glass has reached stage 1 and is heated, the glass will lose weight by the amount of water adsorbed, but there

[1] Presented before the Glass Division of the American Ceramic Society, February 24, 1920.

[2] O. Schott, *Zts. Instrumentenkunde*, **9**, 86–90 (1880); F. Foerster, *Ber. deutsch. Chem. Ges.*, **26**, 2915–2922 (1893); *Zts. anal. Chem.*, **33**, 299–322, 322–335 (1893); F. Mylius and E. Groschuff, *Zts. anorg. Chem.*, **55**, 101–118 (1907).

will be no change in character of the surface no matter how rapidly it is heated. Under the time and temperature conditions of his experiment, Schott's Jena Glass 15''' had reached only this stage. My glass[1] BL. 100 was still in this stage after 20 minutes heating with water at 225°. At 30 minutes it had reached stage 2.

If a glass has reached stage 2 the character of the resultant surface will depend, given equal quantities of water absorbed, on the rate of drying and on the mechanical properties of the glass, such as its hardness, density and tensile strength. On quick heating the glass surface will show a fine pattern of cracks (sometimes microscopic), coarse isolated cracks, splinters, or chips. The surface, however, will show no chemical change. Under the conditions of Schott's experiments most of his glasses reached this stage. My glass BL. 100 reached this stage in 30 minutes, and stage 3 in 45 minutes.

Glasses which have reached stage 3 will usually, but not always, show signs of chemical action, such as a translucent skin, even without further heating. With certain glasses, usually potash glasses (according to Foerster), the chemically different surface layer may still be transparent or semi-transparent, and it would take a careful microscopic examination or determination of the refractive index to determine whether the glass had been acted on chemically. What takes place when a glass which has reached stage 3 is heated is very complicated, depending on both the chemical and mechanical properties of the glass. As has been said, some potash glasses give an amorphous transparent skin, which may be considered opaline silica bound together with potassium silicate. This skin when dehydrated becomes opalescent and semi-transparent, and chips off, sometimes with large surface flakes and grains; and sometimes, as a result of very slow alternate wetting and drying, especially in glasses containing a large amount of lime, it comes off in the form of bubbles or

[1] See preceding article. Besides water, other substances are adsorbed and react on glass surfaces, affecting markedly their reflecting power. H. D. Taylor, "Adjustmen and Testing of Telescope Objectives," York, England, 1894; F. Kollmorgen, *Trans. Illum. Eng. Soc.*, **11**, Pt. I, 222–234 (1916). Also unpublished experiments by F. E. Wright and J. B. Ferguson.

films which separate rather sharply from the untouched glass below. Often these bubbles or films show both the Newton and opal colors and strongly resemble Roman glass. Thus the glass bottle illustrated in figure 1 (a Greiner and Friedrichs "Re-

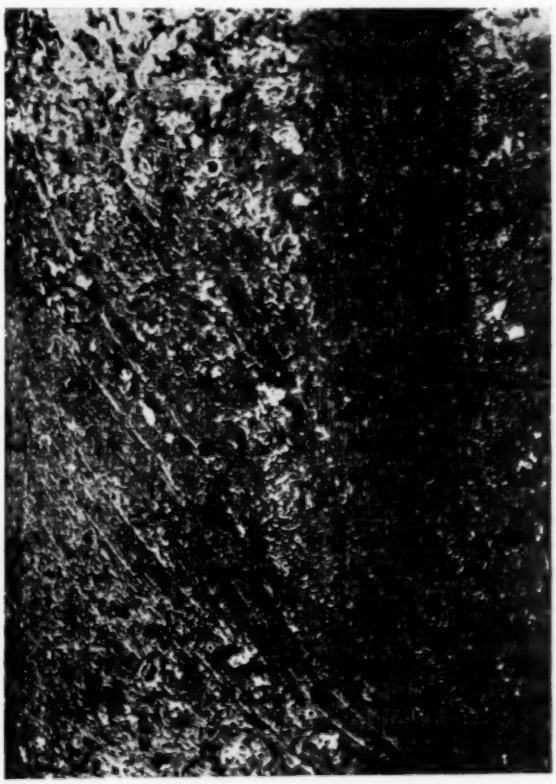


FIG. 1.

sistenz" bottle which had been exposed to hot water and to steam alternately for more than three months) shows brilliant Roman color effects. Here the hydrated and more or less plastic silicate film has separated from the glass underneath in the form of innumerable bubbles of unusually large size. The illustration is magnified 4 diameters. On the other hand, certain soda

glasses, when heated after reaching stage 3, flake off hard particles like sand, or form deep cracks in an enamel-like surface, and show other peculiarities which can readily be accounted for on the basis of this theory.

The appearance and behavior, on heating, of glasses in stages 4 and 5 are, of course, obvious. Stage 4 was reached in glass BL. 100 in 60 minutes. The time needed to reach stage 5 has no significance.

The theory outlined here for weathering with water is probably applicable to all weathering of glass, but the weathering due to other agents has not come under the author's experience.

GEOPHYSICAL LABORATORY
CARNEGIE INSTITUTION OF WASHINGTON
July, 1919

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

A SATISFACTORY METHOD OF USING BARIUM HYDRATE IN TERRA COTTA BODIES

By M. E. Gates

The usual method of using barium carbonate in a terra cotta body is to calculate the amount of barium carbonate necessary to take care of soluble salts in the body, and, using this as a basis, to add 100 per cent extra of the barium carbonate to take care of variations in the amount of soluble salts.

In the use of barium hydrate this same rule can be applied, if it is thought advisable. By this we mean that we have never experienced any difficulty with barium hydrate when used to the extent of two or three times the ordinary amount. The reason for this seems to be that:

1. Barium hydrate is very nearly insoluble in water. One-half of 1 per cent barium hydrate to clay, if added to the total mixing water, would mean only a solution of about 2 per cent barium hydrate to water by weight. This would be the proportion with the ordinary terra cotta body of 66 per cent clay and 33 per cent grog. Using the barium hydrate under these conditions we find it to be too insoluble for uniform results, *i. e.*, the barium hydrate if mixed in the free water tank would result in the solution coming from the tank not being uniform.

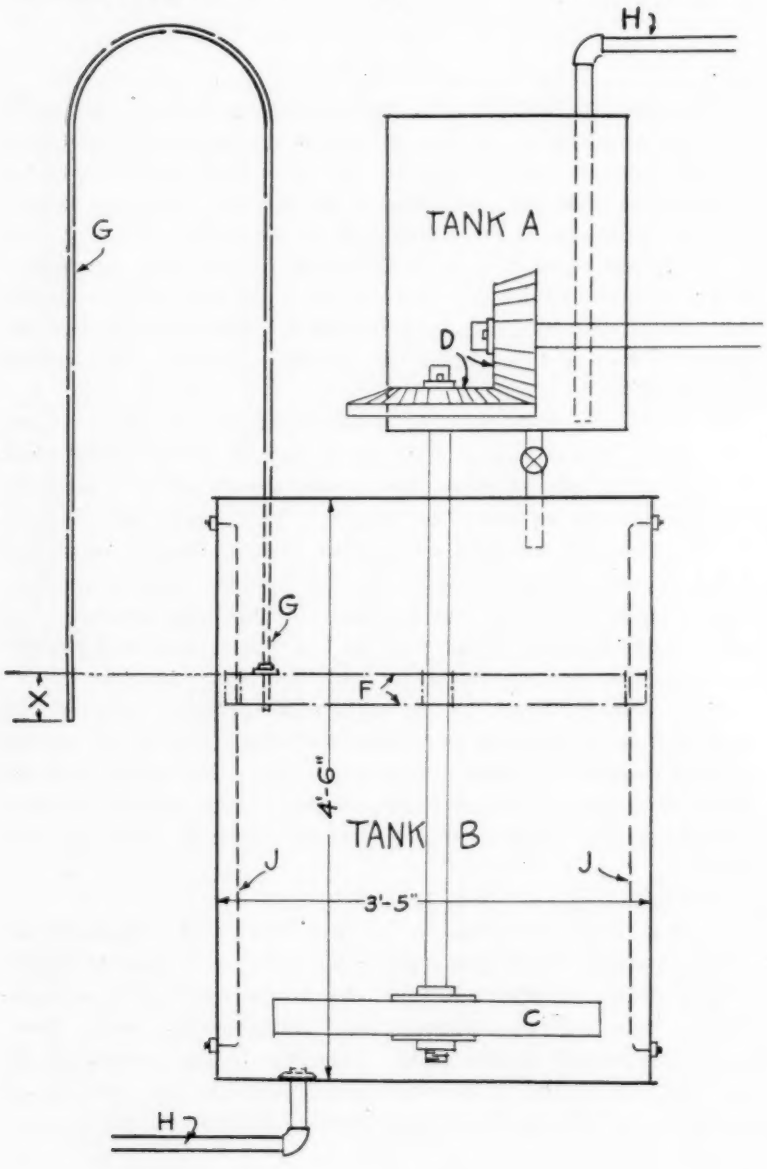
2. If it should come to the surface of the terra cotta it will immediately be changed to barium carbonate, due to the action of the air upon it. There are instances where the barium hydrate has come to the surface, and left a white scum, mostly on the projecting corners. This, however, does not seem to cause any bad effect.

The advantages of using barium hydrate are:

1. That it is not necessary to add this extra proportion of barium hydrate to do away with the ordinary scumming which is encountered with soluble salts, due to the fact that it is more soluble than barium carbonate and consequently comes more easily into contact with the salts. Therefore, it is more economical.

2. Barium hydrate is so nearly insoluble in the per cent (about 14 per cent) solution and temperature of mixture we use that we

had to devise means for keeping it in solution until we could get it into the body mix.



Our method of applying barium hydrate is the result of two or three years of study. The machine we have devised is shown on the accompanying drawing, in which "A" is the preliminary mixing tank for dissolving the barium hydrate, which later is drawn into tank "B" through a valve and pipe. In "B" we have a paddle wheel "C" driven by the gears "D," this paddle revolving at the rate of nine revolutions per minute. The tank "B" is 3 feet 5 inches in diameter, 4 feet 6 inches high. The paddle wheel "C" is revolved at all times during the use of the mixing machinery, so as to keep the solution as near constant as possible. We have a steam pipe "H" connected to the tank "B" to warm the mixture in case it becomes too cold. It is necessary to keep this above a certain temperature, depending upon your mixture, or the material will crystallize. For feeding from the tank "B" to the mixing machine we have a syphon pipe "G" supported by the float "F." The outside lower end of this pipe "G" extends below the level of the liquid in the tank "B" by the distance "X." Changing the difference in the dimension "X," of course, changes the amount of flow per minute. The pipe "G" is made so that it can be picked up from the float "F." This is for the purpose of being able to keep it clean. If it is left in the mix the barium hydrate will crystallize in it, and, therefore, stop the flow, and consequently change the value of the dimension "X" of the syphon. The float "F" must, of course, move freely up and down with the level of the liquid in "B," which is accomplished by guide rods "J."

This system has been in use for five years, with very few changes. It gives excellent results, without any technical supervision, the clay-mixing foreman being able to attend the machine himself, and to check the quantity of barium hydrate he is putting into his mix—adding so many pounds of barium hydrate every inch he fills his tank. He simply establishes a rule that every so many hours or minutes run, the level in the tank "B" should change a corresponding amount.

THE AMERICAN TERRA COTTA AND CERAMIC COMPANY
TERRA COTTA, ILLINOIS
January, 1920

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

TITANIUM ENAMELS

By Robert D. Landrum and Leon J. Frost

Titanium oxide is a ceramic material which has received little, if any, mention in American enamel literature. It is used by the enameler as rutile, in which form it contains iron oxide (Fe_2O_3) as the principle impurity. Rutile has a brown color although the pure oxide is nearly white.

In Vol. 42 (p. 598) of Sprechsaal, Vondracek gives the following under the heading, "Titanium as an Opacity Producing Material."

"An opacifying material standing very near to oxide of tin is oxide of titanium. The best known source of this material is rutile, which consists essentially of titanium oxide (TiO_2) with iron and some silica and alumina as impurities. When used in a glass or enamel there is a great tendency for a yellowish color to develop even though only a small per cent of the material may be used. This coloring action is evidently caused primarily by the impurities, iron and possibly chromium, but secondarily by a reduction of the TiO_2 to a lower oxide of a yellow color by any reducing materials or gases in the mixture.

"Leuch has patented the process of partially replacing the silica in glasses by titania and if this be free from impurities and melted in an oxidizing atmosphere a colorless (*i. e.*, not opaque) glass will result. Such a glass has the following properties:

"1. It melts at a lower temperature than those with all silica.

"2. It withstands the action of acid vapor much better, even though but little titania is present. (One molecule of TiO_2 to two molecules of SiO_2 is very resistant to acids.)

The addition of titania to a glass, therefore, seems to combine the good properties of a high silica glass and a low silica glass containing boric acid, lead, or fluorine, for such a glass withstands the action of acids as well as the former and melts and flows as easily as the latter. The specific gravity of such a glass is much higher and its refractive power is also greater (they are very glossy).

Opacity is caused by the addition of larger proportions of titania, and this point is of special interest to enamelers. Artificial, technically pure, TiO_2 becomes insoluble in the enamel upon heating to redness and cooling slowly so as to allow an invisible crystallization to take place, thereby developing opacity. When used in this connection it is a good substitute for tin oxide.

Philipp Eyer in his book "Emaile Wissenshaft" confirms most of the above points and emphasizes especially the detrimental discoloration. Drs. Hillringhaus and Heilman, however, in their patent 207,001 (German) claim to get away from the yellow color by the addition of cobalt oxide. The patent reads in part: "Research has proven that by the addition of cobalt oxide to a titanium enamel it is possible to prevent this yellow cast and to obtain a nearly white enamel. Previous literature has held that titanium oxide gives a yellow-green when used in combination with cobalt oxide. As a result of this fact no attempt has been made in the enamel industry to secure the complimentary blue color from this source, in spite of the great need of a means of masking the yellow. Therefore, the application of TiO_2 has been neglected and the expensive SnO_2 has continued in use. The researches which lead to the above discoveries have established the falsity of the previous statements."

"In applying the above principle a small amount of cobalt oxide is added either to the TiO_2 itself or to the enamel containing it previous to smelting; or, a bright blue flux may be prepared and this used in the enamel mix or added to the titanium itself previous to the mixing.

"By means of this procedure it is possible to displace the expensive and less acid resisting tin glaze with the cheaper and more durable titanium enamel."

A number of titanium enamels have been made for the purpose of confirming some of the above statements and in the hope of throwing some light on the practical working compositions containing this material.

The first series, A, figure 1, consists of five enamels (really glasses in character) published by Vondracek. In as far as was possible with the enamels under consideration, the same methods of manufacture, testing and reporting used by one of the writers

ENAMEL	GRAPHIC FORMULA	SMELTING TIME	MILLING	FRIT	OPACITY	ACID LOSS	HEATING TESTS	IMPACT	GLOSS	REMARKS
1	.488 Na_2O .066 K_2O .446 CaO } .445 TiO_2 { 1.263 SiO_2	20 MIN	6% SnO_2 7% Clay ¼% MgO	Yellow Tint Clear Heavy	Very Poor	None (No effect)	Very Excl.	Good	Excl.	This glaze Is exceptionally durable
		34.	26% 23.	40% 20	17% 6.	05%	16	12%		
2	.507 Na_2O .030 K_2O .463 CaO } .463 TiO_2 { 1.233 SiO_2	20 MIN	10% Clay ½% MgO	Yellow Green Clear Heavy	Very Poor	None (no effect)	Very Good	Good	Excl.	Similar to # 1
		34	08% 24	75% 21	34% 2	77%	17	06%		
3	.488 Na_2O .066 K_2O .446 CaO } .446 TiO_2 { 1.338 SiO_2	21 Min	10% Clay ½% MgO	Pale Green Clear Heavy	Very Poor	None (No effect)	Very Good	Very Good	Good	Similar to #1 & 2
		35	57% 22	92% 19	77% 5	93%	15	81%		
4	.726 Na_2O .055 K_2O .219 CaO } 166 TiO_2 { .663 SiO_2 .588 B_2O_3	15 MIN	20% Clay 1% MgO	Pale Green Soft	Not Comparable				Good	Of no value as an enamel
		16	88% 32	63% 9	29% 4	67% 30	90% 5	63%		
5	.612 Na_2O .092 K_2O .296 CaO } .558 TiO_2 { .280 SiO_2 .664 B_2O_3	12 MIN	20% Clay 1% MgO	Green Soft	Poor Uneven Crystallized	Not Tested	Fair	Good	Good	Exceptional fire resistance and long burning range.
		6	54% 25	26% 11	53% 7	23% 32	05% 17	39%		
			QUARTZ	SODA	CALCITE	SALTPETER	BORICACID	RUTILE		

FIG. 1.

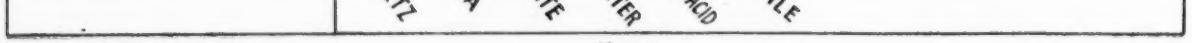


FIG. 1.

ENAMEL	GRAPHIC FORMULA	SMELTING TIME	FRIT	MILLING	OPACITY	ACID LOSS	HEATING TESTS	IMPACT	GLOSS	REMARKS
6	.489 Na_2O .066 K_2O .445 CaO } .445 TiO_2 { 1.263 SiO_2 .066 Sb_2O_5	25 MIN 31	Ivory Very Opaque Heavy .66%	10% Clay ½% MgO	Quite Good 5	None 59% 18	Very Good 69%	Very Good 14	Excl. 88%	Difficult to apply 18 61% 10 57%
7	.487 Na_2O .066 K_2O .447 CaO } .145 Al_2O_3 { 1.267 SiO_2 .447 TiO_2 1.320 F_2	25 MIN 33	Ivory Very Opaque 50%	6% SnO_2 7% Clay ½% MgO 27	Very Good 12% 5	.0017 Gr. 91% 2	Poor 33% 15	Good 37% 15	Good 77%	The failure in heating test caused by corrosion of ground coat.
8	.742 Na_2O .078 K_2O .180 CaO } .300 Al_2O_3 { 2.444 SiO_2 .371 TiO_2 .768 F_2 39	18 MIN 72 20	Yellow Brown Med. Uneven Opacity 11%	6% SnO_2 7% Clay ½% MgO 13	Good 81%	None 12	Very Good 28% 4	Very Good 31% 9	Very Good 77%	This enamel worked well.
9	.672 Na_2O .142 K_2O .186 CaO } .310 Al_2O_3 { 2.521 SiO_2 .398 TiO_2 .794 F_2 39	16 MIN 14% 19	Creamy White Med. Opacity 34%	6% SnO_2 7% Clay ½% MgO 13	Good 70% 3	.0006 gr. 94% 8	Good 98% 4	Poor 26% 10	Very Good 04%	Failure of impact test due to defective ground Enamel worked well.
10	.536 Na_2O .146 K_2O .318 CaO } .332 Al_2O_3 { 2.710 SiO_2 .152 B_2O_3 .270 TiO_2 1.067 F_2 36	40 MIN 60% 22	Creamy White Good Opacity 19% 7	6% SnO_2 7% Clay ½% MgO 15% 15	Quite Good 74% 3	.0024 gr. 92%	Excl. 7	Very Good 08% 6	Very Good 38%	A very durable enamel. 94%

FELDSPAR · QUARTZ · BORAX · CRYOLITE · SALTPETER · SODA ASH · FLUORSPAR · RUTILE · BORIC ACID · CALCITE · $Na\,Sb\,O_3$

FIG. 2.

in "A Comparison of Ten White Enamels for Sheet Steel," Vol. XIV of the *Transactions*, were followed out. The corrosion test was the same in every case, 20 per cent by volume acetic acid being used. In calculating the molecular formulas the rutile was considered as being pure TiO_2.

These compositions were all very difficult to work as enamels and probably have no practical value as such. The principal difficulty was in keeping them suspended properly, due to the high specific gravity of the frits. They do, however, serve to show to what extremes titanium compositions might be carried and give some idea of the resulting properties.

The enamels of series B, figure 2, were made for the purpose of finding out something of the working and the properties of rutile enamels of more nearly a normal composition.

Conclusions

Some of the conclusions drawn from the above and other trials of this enamel material, which can not be given, are as follows:

I. A too high content of TiO_2 increases the specific gravity of a frit to such an extent that it is extremely difficult to keep it in a satisfactory state of suspension by ordinary means.

II. The extent of the yellow discoloration is not directly proportional to the amount of rutile and nitrate in the enamel, but seems to depend also upon other chemical balances not yet determined. Thus an enamel with a large amount of rutile and the proper per cent of nitrate may have less discoloration than one with correspondingly less of each material.

III. The opacity is also somewhat independent of the amount of rutile present. As claimed by Vondracek, TiO_2 does precipitate out of the molten solution in the form of invisible crystals, but the extent of this crystallization is, we believe, more dependent on the composition of the enamel than on the exact amount of TiO_2 present. Just what the most suitable compositions are has not yet been determined; but apparently the presence of B_2O_3 is desirable, although this constituent may be replaced entirely by TiO_2 as far as most of the resulting enamel properties are concerned.

IV. The theory of the opacity from TiO_2 by means of its precipitation within the enamel is backed by the fact that some rutile enamels are easy to overburn, especially when they are opaque and in the absence of tin oxide.

When a certain excess of crystals have formed within the enamel, they appear to break through the surface with a consequent loss of gloss. This one point might limit to some extent the procurement of the maximum opacity from TiO_2 in the melt.

V. The most promising feature of the possible use of rutile is shown by the fact that practically all enamels containing it show unusual durability under all tests. The chemical resistance is always greatly superior to the ordinary kitchen ware enamel, and the very high gloss which many of the enamels develop makes a surface which is especially resistant to abrasion and the consequent failure of the enamel after the surface is once broken. The heat resistance is also greatly improved and the resistance to impact is fully as good as is found with other average enamels.

VI. Preliminary experiments indicate that TiO_2 has no place in a ground coat. When 0.1 molecule of TiO_2 was added to a normal ground coat, the cobalt blue was somewhat destroyed, the melting point was so lowered as to cause burning off, and the enamel did not combine properly with the steel. The elasticity remained as good, however, and possibly was somewhat improved.

VII. The direct addition of 1 per cent of cobalt oxide to enamel 1 of series A did not result in any of the usual ground coat properties. The enamel was softer, more brittle, did not burn down properly and had very little adherence.

By way of final conclusions, we might say that the good qualities resulting from the use of titanium seem to more than offset the bad ones and it seems possible to overcome some of the difficulties and develop enamels of very substantial practical value.

CLEVELAND, OHIO
February, 1919

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

NOTE ON COBALT OXIDE

By N. B. Davis

The history of the use of cobalt compounds as coloring agents in the ceramic industry takes one back to the early days of the Chinese civilization. The early potters were satisfied with cobalt in the form of the original ore, roasted, or in crudely made silicate melts, while the modern ceramist must have his cobalt in the highly concentrated from of oxide.

For many years the world's supply of cobalt was drawn from the cobalt-silver deposits of Saxony, and about the year 1790 the annual production of smalt blue, containing approximately 6 per cent of cobalt, was 300 tons. With the discovery and development of the nickel deposits of New Caledonia metallurgical processes were perfected for the separation of cobalt, and for some time prior to 1903 most of the world's supply came from these ores.

Between 1903 and 1908 some cobalt oxide was produced from the lead-nickel-copper-cobalt ores of Missouri, but since 1905 the greatest source of oxide has been the cobalt-silver district of Canada. The Canadian production now shows signs of decline, and it is interesting to note that the deposits of Missouri are coming to the fore again. Under new management, and with the experience gained in the metallurgy of Canadian ores, metallurgical processes have been worked out to save lead, nickel, copper and cobalt, and the American ceramic industry is no longer wholly dependent on foreign supplies.

The following table shows the cobalt oxide produced and imported into the United States:

Production and Imports of Cobalt Oxide

Year (a)	Production pounds	Imports pounds	Year (a)	Production pounds	Imports pounds
1869.....	811	.....	1894.....	6,763	24,020
1870.....	3,854	.....	1895.....	6,400	36,155
1871.....	5,086	.....	1896.....	12,825	27,189
1872.....	5,749	.....	1897.....	19,300	24,771

1873.....	5,128	1,480	1898.....	9,640	33,731
1874.....	4,145	1,404	1899.....	10,200	46,791
1875.....	3,441	678	1900.....	12,270	54,073
1876.....	5,162	4,440	1901.....	13,360	71,969
1877.....	7,328	19,752	1902.....	20,870	79,984
1878.....	4,508	2,860	1903.....	120,000	73,350
1879.....	4,376	7,531	1904.....	22,000	42,353
1880.....	7,251	9,819	1905.....	(*b*)	70,048
1881.....	8,280	21,844	1906.....	12,887	41,084
1882.....	11,656	17,758	1907.....	487,358	42,794
1883.....	1,096	13,067	1908.....	663,101	1,550
1884.....	2,000	25,963	1909.....	986,767	9,818
1885.....	8,423	16,162	1910.....	494,975	6,124
1886.....	8,689	19,366	1911.....	340,977	22,934
1887.....	5,769	26,882	1912.....	318,804	31,848
1888.....	7,491	27,446	1913.....	22,151	28,729
1889.....	12,955	41,455	1914.....	.....	109,484
1890.....	6,788	33,338	1915.....	.....	190,145
1891.....	7,200	25,483	1916.....	.....	238,934
1892.....	7,869	32,833	1917.....	.....	236,822
1893.....	8,422	28,164	1918.....	.....	.....

Note (*a*). Production is stated for calendar years, imports for fiscal years ending June 30 until 1887, and for calendar years subsequently.

Note (*b*). Since 1905 the total production of mixed cobalt and nickel oxides of the cobalt smelters of the Canadian Copper Company was shipped to the U. S. to be refined, and is given in the above table under the head of production. The actual production of refined oxide was probably not more than 50 per cent of these figures.

The annual consumption of cobalt oxide in the United States amounted to approximately 240,000 pounds, and although the sum of the figures in the table does not equal this amount, except in a few years, this is merely because the cobalt materials imported were classified as some product other than cobalt oxide, *e. g.*, cobalt ore, and zaffer. Zaffer is a term applied to finely ground roasted cobalt ores or products.

Metallurgy of Cobalt

Cobalt ores may be separated into two classes, *viz.*, straight sulphides or arsenical ores. Both ores are treated by blast furnace smelting to produce a speiss from arsenical ore, and a matte from a sulphide ore. In this operation most of the iron,

sulphur and arsenic are removed although a certain amount of iron is always allowed to enter the speiss or matte.

The speiss or matte then undergoes further treatment for the recovery of silver, cobalt, nickel, and copper. Sulphuric acid is used to leach the cobalt and nickel, but at the same time small quantities of iron, arsenic, and sulphur dissolve and must be removed.

When copper is present in important amounts, it is removed as metal by electrolytic means. When present in a very small amount it is eliminated along with iron by the addition of calcium carbonate. The subsequent separation of cobalt and nickel is attained by the addition of bleaching powder resulting in the precipitation of cobalt hydroxide, and the nickel is in turn precipitated by the addition of lime or sodium carbonate. The resultant black cobalt oxide will contain up to 0.5 per cent iron; 1 per cent nickel; with copper, arsenic, and sulphur 0.1 per cent each.

The cobalt hydrate is heated at low temperature to form the cobalto-cobaltic oxide (mixture of Co_3O_4 and Co_6O_7) which is black in color. This is the material supplied to the ceramic trade of U. S. and Europe. By subjecting the black oxide to temperatures around 1000° C. oxygen is driven off, and the resultant material is largely cobalt monoxide, gray in color. This gray oxide is the form in which cobalt is supplied to the trade of Japan and China.

The various salts are prepared by treating the oxide with suitable acids, the analyses of which show the following content of cobalt metal:

Black Oxide	70%
Gray Oxide	75
Cobalt Arsenate	29
Cobalt Carbonate	50
Cobalt Phosphate	34

Uses of Cobalt

Up until a few years ago the ceramic industry was the chief consumer of cobalt oxide, but recent developments in the use of cobalt metal in the manufacture of cutting tools and in the preparation of driers for soya bean oil suggest the possibility of the ceramist having to share the limited resources of the element.

In the ceramic industry the chief value of cobalt is as a coloring agent in the decoration of glass and pottery. Large quantities are consumed by the enameling sections of the trade, and a small amount added to the general body mixtures for white ware to counteract the yellow color of iron.

The tool metal trade is taking an increasing amount of cobalt metal for use in the making of Stellite, an alloy of cobalt, tungsten, and chromium. And again, the paint and varnish industry has recently found a wider use for soya bean oil through the application of cobalt linoleate as a drier. This comparatively recent development bids fair to replace linseed oil by soya oil in large measure.

Future Conditions

The price of cobalt oxide prior to 1907 varied from $1.60 to $2.00 per pound (70 per cent metal), but in 1907 the price rose to $2.50 per pound. In the following years there was an overproduction from Canada and New Caledonia, resulting in a decline to an average of 90 cents in 1915. As the demand increased the price advanced to the present day quotation of $1.50 per pound.

Looking into the future and taking into consideration the rapid growth of ceramics, tool metal manufacture, and the requirements of the paint and varnish trade, there is every indication that the price of cobalt oxide will advance. As the world resources are known to be limited in extent, and the output from most of the largest productive centers is falling off, it will probably require higher prices to develop fresh deposits.

NOTE.—For details of the subject of cobalt, its occurrence, properties and uses, the reader is referred to the recent monograph by Dr. C. W. Drury, published by the Ontario Bureau of Mines, **27**, Part III, 1918.

CERAMIC ABSTRACTS

General

Melting point methods at high temperatures. I. LEO I. DANA AND PAUL D. FOOTE. *Chem. and Met. Eng.*, **22**, 23–29 (1920).—Use of Thermo-Electric Pyrometers, Pure Materials. Of all crucible materials used for pure metals Acheson graphite has the greatest utility. It is very pure, can be machined into any desired shape, and is not attacked by most of the common metals. Crucibles of magnesia, alumina or mixtures of the two are suitable for iron and nickel. Porcelain crucibles may be used for many of the metals, but there is always danger of these cracking when the metal melts or freezes. Up to 500° C. protection tubes and insulating tubes for the couple made of pyrex glass are useful. From 500 to 1100° C., lower grade porcelain glazed on the outside only or fused quartz are satisfactory. Above 1100° C. tubes having a composition approximating that of sillimanite, Al_2O_3, SiO_2, are recommended. The more common metals which can be used for the standardization of thermocouples by the crucible method, with their melting point in °C are: Tin 231.9, bismuth 271, cadmium 320.9, lead 327.4, zinc 419.4, antimony 630.0, aluminum 658.7, silver 960.5, gold 1062.0, copper 1083.0, nickel 1452. Furnaces wound with "Chromel A" wire are used up to 1000° C. In alloys and mixtures if the ordinary temperature-time curve does not give evidence of a melting range or of a transformation point, the more sensitive inverse rate method and differential method may be employed. The former consists in determining the time required for the specimen to fall a definite temperature interval, and in plotting this time against the temperature. The differential method is still more sensitive and consists in measuring the temperature differences between the material in which the transformation takes place and a neutral body having no transformation points in the same temperature interval, such as platinum or nickel, and plotting this difference against the temperature of the material. H. P. NIXON.

Melting point methods at high temperatures. II. LEO I. DANA AND PAUL D. FOOTE. *Chem. and Met. Eng.*, **22**, 63 (1920).—The use of optical pyrometers is necessary above 1550° C. The disappearing filament type is most satisfactory. Melting points of refractory oxides in °C. are: MgO 2800, CaO 2570, Al_2O_3 2050, Cr_2O_3 1990. For technical testing the criterion of marked flow is usually taken to define the so-called melting point for refractory mixtures and even for pure crystalline compounds; on the basis of such a definition the melting point of quartz is about 1750° C. Crushed carbon, graphite, kryptol, or carbon plate resistor furnaces do not permit of very precise regulation. The vacuum furnace of the Arsem type

is more desirable on account of its freedom from smoke and because good control is possible at extreme temperatures, even at 2500° C. Seger and similar cones serve a useful purpose under slow rates of heating in measuring heat effects during the firing of ceramic products, but in the laboratory, when the rates of heating are comparatively rapid and may vary considerably, the determination of the cone softening point is not of much significance.

MELTING POINTS OF COMMON REFRACTORY MATERIALS

Fire bricks	°C.	Clays and sands	°C.
Fire clay	1500–1750	Kaolin, $Al_2O_3.2SiO_2.2H_2O$	1740
Silica	1700–1750	Fire clays	1400–1740
Magnesia	2150	Bauxite clay	1800
Bauxite	1600–1800	Bauxite, $Al_2O(OH)_4$	1820
Chromite	2050	Chromite, $FeO.Cr_2O_3$	2180
Miscellaneous			
Coal ash	1100–1500	Silica	1750
Alundum cements	1750–2000	Silica sands	1700–1750

H. P. NIXON.

Research associations, growth of, in England. Staff article. *Chem. Met. Eng.*, **22**, 264 (1920).—Under the British Government's plan, whereby $4,866,500 is made available for industrial research, research associations have been formed in connection with a large number of industries including the portland cement and glass industries. The scientific and industrial research department has given its sanction to the formation of similar associations for refractory materials. Before any association can come under the government scheme, the associations must be national in character and include the bulk of the manufacturers in any specified industry. The general scheme is to provide £1 from the department for every £1 subscribed by members up to five years after organization; but should an association's expenditure exceed £6,000 a special arrangement may be agreed to.

A. J. LAMBERT.

Insulating materials, electrical resistance of various, at high temperatures. R. K. HONEMAN AND E. L. FONESCA. *Report* No. 53, National Advisory Committee for Aeronautics, p. 15.—In very hot high-compression engines spark plugs may fail because the core becomes a conductor of electricity. The ignition current then flows through the body of the plug instead of causing a spark at the terminals. To secure definite and repeatable results on this property, it was found necessary to make the measurements with alternating current, using a 500-volt, 60-cycle supply. In this way the disturbing effect of polarization, etc., is avoided. The conductivity of this class of materials increases very rapidly with temperature according to the law of compound interest at a rate of about 2 per cent per degree centigrade. The most convenient basis of comparison for different materials is the "effective temperature" (Te) to which they must be heated in order to reduce their resistivity to a definite value, arbitrarily taken as one megohm per cm. cube. A spark

plug of normal design with material of this resistivity would have a resistance of about 200,000 ohms. This value is only slightly above the limit at which the usual ignition system can be counted on to fire a plug. The effective temperature thus defined varies from 870° C. in case of fused quartz (the best material tested) down to 280° C. for some kinds of glass. Porcelains have been developed at the Bureau of Standards ceramic laboratory which have an effective temperature as high as 800° C. Certain bodies recently developed for use in aviation engines have temperatures of about 650° C., while the majority of spark-plug porcelains have 500° C. A material having Te less than 400° C. should be used only when the design of the plug is such that the insulator is extremely well cooled. The Te temperature in C° for typical materials is as follows: Fused silica 890; best porcelain tested 790; typical mica plug 720; average of three aviation porcelains 650; average automobile porcelain 490. H. G. SCHURECHT.

American bond clays, the properties of and their use in graphite crucibles and glass pots. A. V. BLEININGER. Bureau of Standards, *Tech. Paper*, **144**. —The properties of American bond clays are described in detail and expressed through characteristic numerical values with special reference to their burning behavior. For crucible making the best clays should show a pore-shrinkage water ratio of not more than 1 : 1; a modulus of rupture for a clay-sand mixture of 1 : 1 of about 325 pounds per square inch; a vitrification point of 1150° C., or lower; no marked evidence of overfiring at 1400° C. and a softening point corresponding to Orton cone 31, or above. For glass pots the best materials should show a pore-shrinkage water ratio of not more than 1 : 1; a modulus of rupture, when mixed with equal weights of sand, of not less than 250 pounds per square inch; a vitrification temperature of approximately 1275° C.; an overfiring temperature not below 1425° C.; and a softening point equivalent to Orton cone 29, or above. It is shown that materials equal in quality to those formerly imported from Germany are available and that by suitable blending any desired combination of properties can be readily produced. The characteristics of natural and artificial graphite are described and means suggested for the control of crucible mixtures. The fact is brought out that the main advantage in the use of German glass pot clay consists in its low fire shrinkage and suggestions are made for obtaining similar conditions with the use of domestic materials and with increased resistance to corrosion. The compositions and the preparation of semi-porcelain and porcelain glass pots are given. The method of casting glass pots as practiced at the Pittsburgh laboratory of the Bureau of Standards is also described. A. J. LAMBERT.

Kaolin, ceramic and paper. H. LERG. *Tonind. Zeit.*, **44**, 103 (1920).— Washed kaolin is passed through long troughs and the portion which sinks to the bottom is used for paper, while the finer kaolin which is carried off by the water is used for ceramic purposes. About two parts of paper kaolin are obtained from three parts of the total. H. G. SCHURECHT.

Osmotic purification of clay. W. R. ORMANDY. *Trans. Ceram. Soc.*, **18**, Pt. II, 327–339 (1919).—The apparatus consists of a wooden trough, fitted with a lining of wire gauze, and a metallic drum which rotates slowly in the trough. At any point clay and water to which has been added a small amount of alkali, can be fed in. An overflow is provided through which the impoverished slip can be discharged. The gauze is connected to one electric pole, and the drum to another, and an electric current is set in motion. A thin deposit of clay forms on the drum, and gets thicker and thicker, and although deposited actually *under the water* the clay is found to come off drier than by the use of an ordinary filter press at a pressure of 150 pounds to the square inch. The cause of the dryness is that the clay particles which are near the electric pole come on to its surface owing to their electric charge and form a very thin layer or skin. This skin, owing to the fact that it is made up of a number of very small particles, consists of a series of capillary tubes, and instantly the water is sent away in accord with the well-known phenomenon (known as endosmosis) of travel of water through capillary tubes under the influence of electric current. Most bodies when placed in water take on a negative charge of electricity. Generally speaking, pyrites and iron oxide are positive, while silica is practically neutral, and clay electro-negative. The addition of a small amount of alkali causes certain particles to accumulate into a smaller number of a larger size due to neutralization of their electric charge, and these settle out rapidly. Purification of clays by deflocculation by the addition of alkalies and sedimentation is used preliminary to osmotic purification. The product which is separated by the treatment is recovered in a comparatively dry state, it has always an increased plasticity, it sinters at a temperature which may be anything up to 300° C., lower than that of the original clay, it shows a greater contraction and has always a higher melting point. A. J. LAMBERT.

Recuperative furnace, a new type of. WALTER ROSENHAIN AND E. A. COAD-PRYOR. *Trans. Ceram. Soc.*, **18**, Pt. II, 407–419 (1919).—See this JOURNAL, **2**, 838. A. J. LAMBERT

Research, industrial at the Mellon Institute. WALLACE SAVAGE. *Chem. & Met. Eng.*, **22**, 249–255 (1920).—Two and one-half years ago the Refractories Manufacturers' Association founded a multiple fellowship at the institute for the main purpose of developing standard tests for refractories. Much valuable information has been obtained on fusion, slag penetration and abrasion, spalling, deformation under load on reheating and volume changes on reheating. In the case of magnesia, extensive investigations are being conducted to develop a domestic product to replace that formerly imported. The effect of the basic fluxes, such as lime, iron oxide, etc., on the slaking, slagging and general stability in use was sufficiently determined to give the data required for the production of satisfactory magnesia products from domestic magnesite. The elimination of the lami-

nated structure in auger machine made brick by repressing the brick on edge is another industrial contribution of this fellowship.

Dr. C. C. Vogt, working on the dental cements fellowship, by the proper blending of metal oxides and such fluxes as feldspar, silica and fluorides, has perfected a new translucent dental cement which has been nationally adopted by the dental profession. J. L. CRAWFORD.

Soap from clay. *Brick Clay Record,* **55,** 533 (1920).—It is reported in England that F. E. Weston has made a long series of experiments in the use of colloidal clay in the soap manufacture. The washing properties of soap derived at present from fatty acids from animals and plants can equally well or even better be partly supplied by colloidal clay. China clay is treated by a special colloidal process through which colloidal clay is prepared. Since the price of soap is largely dependent upon the proportion of fatty acids it would seem that the substitution of colloidal clay for these would cheapen the cost of soap. It is not contended that these fatty acids can be dispensed with entirely by the use of colloidal clay; but their present proportion could be reduced one-half by the substitution of colloidal clay.

H. G. SCHURECHT.

Refractories

Bricks, preventable defects in refractory. C. E. NESBITT AND M. L. BELL. **19,** Part II, 620–629.—The strength of a brick is greatly reduced by penetration of slag. A dense brick is advocated. Tests made for slag resistance on experimental power-pressed silica brick show approximately 25 per cent less penetration by heating furnace slag than hand-molded brick. Silica brick shows a marked falling off of from 50 to 60 per cent in crushing strength when heated to 1350° C. A group of 85 standard 9-in. silica bricks were subjected to visual inspection; 16 were judged to be of low strength because of visual defects; 18 were considered to be of medium strength, while the remainder were passed as being good. These bricks were then subjected to a hot crushing test. All bricks were crushed at 1350° C., with the result that the average strength for the 16 defective bricks was 677 lbs. per sq. in., 861 lbs. for the medium and 991 lbs. for the good bricks. True specific gravity and porosity tests tell only the degree of burning—D. W. Ross, "Silica Refractories," *J. Am. Ceram. Soc.*, 1, 477 (1918). Bricks which have the same true specific gravity do not have the same crushing strength or spalling value. Uniformity of product is important. A. J. LAMBERT.

Fire clay, the use of, in laying fire clay brick. R. M. HOWE. *Clayworker,* 136–137 (1920).—Certain materials such as cement and sodium silicate are sometimes added to fire clay mortars in laying fire clay brick in order to reduce the shrinkage and to prepare a mortar which will harden without burning. The effects of these ingredients on the fusibility of a cone 30 bond clay were studied and the results are given below.

DEFORMATION POINT OF THE MIXTURES EXPRESSED IN CONES

Per cent material added	Portland cement	Lime	Asbestos	Water glass	Salt	Carborundum	First grade fire-brick bats
0...	30	30	30	30	30	30	30
3...	..	..	28–29	..	..	..	..
4...	27	20–26	..	29–30	..	..	..
5...	..	..	..	..	26	29	..
6...	20	..	19–20	..	..	..	..
8...	19	17–18	..	29	..	..	..
9...	..	..	18–19	..	..	..	..
10...	15	..	..	..	14	29	..
12...	..	11	..	28–29	..	..	..
15...	..	..	..	..	5	29	..
16...	..	10	..	26–27	..	..	..
20...	13	..	..	26	..	29	..
24...	..	..	..	20	..	..	..
25...	..	..	..	..	..	..	30–31
30...	11	..	..	..	..	29	..
40...	8	..	..	..	..	29	..
50...	..	..	..	..	..	29	31

The additon of first quality brick bats to the bond clay produced the most refractory mixture. The writer emphasizes the harmful results obtained by the addition of certain foreign materials like Portland cement and asbestos, which greatly decrease the refractoriness of the mortar. Arches with a thick mortar containing 10% each of asbestos and water glass failed at 1250° C., due to softening of the mortar. The use of an extremely thin layer of mortar is recommended. H. G. SCHURECHT.

Crucible graphite. Staff article. *Chem. and Met. Eng.*, **22**, 220 (1920).—Graphite for making crucibles should be of the crystalline variety and should have a high degree of purity. Most makers of crucibles prefer to use Ceylon graphite either alone or mixed with varying proportions of American flake, usually not exceeding 25% of the mixture. The more nearly cubical fragments of Ceylon graphite have a much smaller surface area in proportion to their volume than the thin flakes of domestic graphite and hence require proportionately less clay as a binder. It is possible, however, to use domestic flake graphite alone with success. The graphitic carbon contents of No. 1 flake should be not less than 85%. Graphitic carbon is the carbon remaining after the dried sample has been burned for 3 min. at 800° C. Screen analysis for No. 1 flake recommended are: Over 35 (standard) mesh—3%, over 65 (standard) mesh—50%, over 100 (standard) mesh—100%.

Although flake carrying 85% of graphitic carbon can be readily produced, the cost of a product containing 90% of graphitic carbon is very greatly increased. A sample of Ceylon graphite prepared for crucible use contained

85.06% of graphitic carbon. In purity, therefore, the American graphite compares favorably with that from Ceylon. The past ten years has seen rapid increase in the manufacture of electric furnace steel, while the production of crucible steel has remained stationary. Recent developments in the electric furnace as applied to non-ferrous alloys also give promise of a rapid decrease in the use of crucibles. H. P. NIXON.

Refractories for glassworks' use, specifications for. W. T. REES. *Trans. Ceram. Soc.*, **18,** Pt. II, 420–430 (1919).—These provisional specifications have been adopted by the Council of the Society of Glass Technology and accepted by the Committee nominated by the Employers' National Council for the Clay Industries. *Tank Blocks:* At the request of the purchaser the following data shall be supplied for his personal information only, together with average samples true to bulk. (*a*) Analysis, showing content of silica, alumina, iron oxide, titanium oxide, lime, magnesia, potassium oxide, and sodium oxide. (*b*) Refractoriness measured by Seger cones. (*c*) Volume porosity. (*d*) Linear contraction or expansion after being heated to a temperature equivalent to cone 14. (*e*) Crushing strength. *Tests.—1. Refractoriness:* Cones cut from the blocks shall not be more fusible than cone 30. The test shall be carried out in an oxidizing atmosphere, the temperature of the furnace being increased regularly at the rate of 50° C. per five minutes. *2. Texture:* The block shall contain no patches of iron-stone or other segregated impurity. They shall be uniformly burnt throughout, and if any blue, black or brown core is present, it shall be of the minimum extent practicable, having regard to the size of the block. The blocks shall be of regular texture and free from holes and flaws. The arrasses shall be as reasonably sharp as is consistent with the size of the grog used. All surfaces shall be sufficiently true and plain as to permit of the blocks being walled together without appreciable joint space on the exposed face. *3. Porosity:* The volume porosity, *i. e.* (the volume of pores × 100) ÷ volume of piece (including pores), shall not exceed: For flux line blocks 18 per cent, for replacement flux line blocks 25 per cent, for bottom side blocks 25 per cent, for tank bottom blocks 30 per cent. *4. After-contraction or After-expansion:* Test pieces (about 3 inches in length and 1 and 2 inches in depth and breadth) taken from any portion of the block after being heated to, and maintained for two hours at a temperature equivalent to cone 14, shall not show when cold more than 2 per cent linear contraction or expansion. When the test temperature has been reached the furnace shall be maintained constant throughout the test period. *5. Crushing Strength:* The blocks shall be capable of withstanding a crushing strain of not less than 1,600 pounds per square inch. The portion of block tested shall be a 4-inch cube and shall have the two ends which come in contact with the jaws of the machine ground or sawn flat and made truly parallel by facing with plaster of Paris in the usual way. *6. Inspecting and Testing:* The purchaser or his representative shall have access to the works of the maker at any reasonable time, and shall be allowed to inspect the blocks before delivery. Duplicate test pieces representative of the bulk of the

material ordered shall be selected prior to delivery. The cost of the blocks damaged for the purpose of obtaining test pieces shall be borne (*a*) by the purchaser when the material is proved satisfactory; (*b*) by the maker, if unsatisfactory. *Raw Clays and Grog.—1. Mixture:* Clay mixture for pots shall consist of at least three portions: (*a*) Bind clay, (*b*) base clay, (*c*) grog. At the desire of the buyer the following data shall be supplied with samples true to bulk. *2. Analysis:* The analysis shall show content of SiO_2, Al_2O_3, K_2O, Na_2O, TiO_2, CaO, MgO, Fe_2O_3, and the loss on ignition. *3. Fusion Test:* This shall record: (*a*) Squatting temperature, measured by Seger cones, with equivalents in °C. and °F. (*a*) Squatting temperature under load in °C. and °F. by standard test to be defined. *4.* (*a*) The bind clay shall be a fat plastic, aluminous weathered clay. (*b*) The base clay shall be a highly refractory clay. Lumps to be specially selected and hand-picked free from pyrites. (*c*) The grog shall be prepared from well-burned pieces of selected refractory clay. Burnt blocks must show no sign of blue-stoning or black core. Nothing of the nature of ordinary fire brick shall be used for grog. *5.* A sample of any portion when made up and fired to 1,400° C. shall not show decided speckling due to iron in a segregated form. *6.* A fracture of each portion, when made up and burnt to 1,400° C., shall show a dense structure, especially the bind clay. A wide range of vitrification is necessary without signs of over-firing. *7.* Clay and grog shall be loaded in clean bags securely tied. *Silica Bricks and Cement.*—At the desire of the purchaser the following data shall be supplied for his personal information only, with average samples true to bulk: (*a*) Analysis, (*b*) refractoriness, (*c*) linear expansion after being heated to cone 12. *1. Composition:* The bricks shall contain not less than 94 per cent of silica, and not more than 2 per cent of lime. *2. Refractoriness:* Test pieces shall not be more fusible than cone 32 (about 1,710° C.). The test shall be carried out in an oxidizing atmosphere, the temperature of the furnace being increased at the rate of about 50° C. per five minutes. *3. After-expansion:* A test piece after being heated to a temperature equivalent to cone 12 for two hours shall not show, on cooling, more than 0.75 per cent linear expansion. *4. Texture:* The bricks shall be uniformly burnt and shall have a regular texture with no holes or flaws. *5. Variations from measurements:* All surfaces shall be reasonably true, and there shall not be greater variation than 2 per cent from any specified dimension. Silica cement shall in all cases be finely ground and suitable for binding together the bricks for which it is supplied. It shall contain not less than 92 per cent of silica and shall be capable of withstanding the same test for refractoriness as the brick. In the discussion emphasis was laid on the fact that these specifications are too stringent in some respects.

A. J. LAMBERT.

Refractory materials, the geology of the, of the North of England. J. B. ATKINSON AND J. T. STOBBS. *Trans. Ceram. Soc.*, **18**, Pt. II, 435–455 (1919). —The fire clays have no doubt accumulated under water from debris washed down by rivers. They are generally but not always associated with coal

beds. A quarry at Pensher in Durham now furnishes blocks of the sand stone called "fire-stone," for the construction of tanks for holding molten glass. It is probable that the highly siliceous ganister rock in this district has long been used in its natural state as a refractory. Ganister rock, generally mixed with fire clay and other materials, for the purpose of making "ganister bricks," would appear to have been first used near Sheffield, about 1858 or 1859. A. J. LAMBERT.

Refractory materials, the standardization of tests for. COMMITTEE REPORT. *Trans. Ceram. Soc.*, **18**, Pt. II, 516–17 (1919).—The penetrative action of slags on fire clays and fire bricks can be conveniently examined in three ways. In the first the clay mixture can be pressed into hollow blocks; outside $2^1/_4$ inches square, $1^1/_2$ inches deep; inside $1^3/_4$ inches deep. The blocks are fired to the desired temperature, say cone 10. When cold, the desired slag is placed in the receptacle and the whole is then again fired to the desired temperature for the desired period of time, say 4 hours. When cold the block can be sawn across. The penetrative and corrosive action of the slag on the mixture will then appear. In the second method a hole, say 2 inches diameter and $^1/_2$ inch deep, is bored in the brick and filled with slag. The whole is then fired and treated as in the previous case. In the third, a ring of stoneware is cemented to a fire brick by means of a thin film of fine grog and silicate of soda mixture. The receptacle so formed is filled with slag and the whole is treated as before. The penetrative action of the slag can then be examined by sawing the brick across. This plan is of general application to fire bricks and gives good results. A. J. LAMBERT.

Mortar refractory. R. KLINGER. *Tonind. Zeit.* **44**, 17 (1920).—A good refractory mortar should increase in strength during service as lime-mortars do when used with building brick. It should not melt at the temperature of the furnace and should show a small fire shrinkage. The chemical analysis should be adapted to the type of brick it is used with.

H. G. SCHURECHT.

Mortar refractory. W. B. SCHEIDT. *Tonind. Zeit.* **44**, 86–87 (1920).—S. discusses paper on "Refractory Mortar" (*Ibid.*, **44**, 17 (1920). Fusion to a certain degree is desirable in refractory mortar as this binds brick together, whereas if the mortar was not fused the brick work would be more or less loose. In furnaces where the mortar is too refractory large cracks occur, due to the expansion and contraction of the brick work due to heating and cooling. H. G. SCHURECHT.

Mortar refractory. R. KLINGER. *Tonind. Zeit.* **44**, 132 (1920).—Cracking of the brick work in furnaces seldom occurs in a new furnace where the mortar is still in an unfused state, while later on when this mortar becomes fused there is a decided tendency for the brick work to crack.

H. G. SCHURECHT.

Silica bricks, factors influencing the properties of. I. ALEXANDER SCOTT. *Trans. Ceram. Soc.*, **18,** Pt. II, 481–596 (1919).—The method of investigation consisted in bonding as pure a silica rock as possible with a small percentage of other material, firing to various temperatures and examining the bricks so made. The silica rock used was vein quartz of a fairly high degree of purity. The bonding materials used were as follows: A, lime (CaO). B, magnesia (MgO). C, alumina (Al_2O_3). D, iron oxide (Fe_2O_3). E, iron oxide (Fe_2O_3) + carbon. F, titanic oxide (TiO_2). G, lime and magnesia. H, lime and alumina. I, lime and iron oxide (Fe_2O_3). J, lime, iron oxide and carbon. K, lime and titanic oxide. L, magnesia and alumina. M, magnesia and iron oxide. N, magnesia, iron oxide and carbon. O, alumina and iron oxide. P, alumina, iron oxide and carbon. Q, lime, iron oxide and titanic oxide. R, Glenboig fire clay. S, china clay. The amount used was 2.5 per cent in the case of the simple oxides, 1.25 per cent of each where two oxides were used, and in Q 1 per cent of each. The carbon was ordinary charcoal and the amounts of E were 2.5 per cent oxide and 0.5 per cent charcoal and in J, N, P, 1.25 per cent of each oxide and 0.25 per cent charcoal. The percentage of unconverted quartz in bricks fired to cone 19 was measured microscopically.

Binder	A	B	C	D	E	F	G	H	I
Quartz %.....	61.4	65.4	76.5	57.1	58.8	68.5	71.2	60.0	51.3
True sp. gr.....	2.51	2.56	2.61	2.51	2.49	2.57	2.57	2.52	2.45

Binder	J	K	L	M	N	O	P	Q	R	S
Quartz %.....	52.1	62.7	65.7	63.3	62.0	52.5	61.7	49.0	58.3	62.0
True sp. gr.....	2.46	..	2.55	2.54	2.55	2.46	2.47	2.44	2.49	2.53

The true specific gravity may be taken as giving a qualitative idea of the amount of conversion, but the quantitative relation is only approximate. As the values for true specific gravity of bricks heated to cone 26 are all practically the same, and approximate to the specific gravity of cristobalite, it may be assumed that most of the quartz has been converted. Hence, it seems feasible to take the after-expansion at cone 26 as indicative of the total expansion of the material during conversion. The ratio of the after-expansion at cone 26 and cone 16 varies from 6.7 to 23.8. Hence, the after-expansion test carried out at cone 16 or lower temperatures may not give even an approximate idea of the expansion which will occur during use. In order to get such an idea it is necessary to heat either to a much higher temperature than cone 16, or for a more prolonged period. In the case of those blocks which contain lime or magnesia as one constituent, final softening is due to the fusion of the mixture of silicates aud fine-grained free silica in the matrix. Where the bond consists of alumina or iron oxide, or a mixture of the two, the matrix and rock fragments seem to fuse simultaneously and the softening point of the piece is practically the same as that of silica. The absence of squatting is due to the high viscosity of fused silica. Fire clay acts in a very similar way. All samples softened at cone 33–36. A. J. LAMBERT.

Silica brick from roof of a basic open-hearth furnace after 135 charges. C. S. GRAHAM. *Trans. Ceram. Soc.*, **18**, Pt. II, 399–406 (1919).—The change in volume of cristobalite at 230° is considerable, consequently mercury dilatometer observations offer a sure way of distinguishing cristobalite from tridymite. The wear and tear of silica bricks in basic open-hearth furnaces is to a certain extent due to the abrasive action of the fine basic dust swept through the furnace by the producer gas. Other factors are high working temperatures, local effects of flame, dust in materials charged, liquid metal from bath and charge, and spurting of the slag during boiling of the bath. The fused material is swept away and fresh surfaces exposed for attack until the bricks are worn away, the maximum wear being near the transverse center of the furnace. The color of the zone exposed directly to the furnace temperature was gray, being followed by a black, a yellow, and a red zone. The gray and black zones were divided by a distinct line of demarcation, while the transition of black to yellow was a gradual one. From yellow to red again was a sudden change.

Zone	Unused brick	1	2	3	4
Depth of zone, inches		1/2	3/4	3-1/4	1-3/4
Color of zone		red	yellow	black	gray
Silica	95.0	93.7	91.4	85.5	88.6
Alumina	1.1	1.1	1.8	1.5	1.0
Total iron, ferric oxide	1.0	1.14	1.52	5.94	5.52
Manganese oxide	trace	trace	trace	.27	.37
Lime	2.5	3.19	4.10	6.06	4.04
Bulk, specific gravity	1.65	1.78	1.80	2.14	2.14
True, specific gravity	2.37	2.41	2.41	2.44	2.42
Porosity, per cent	30.4	26.1	25.3	12.3	11.6

Microscopic examination showed structures similar to those described by others. A. J. LAMBERT.

Glass

Glassware, present status of American. E. C. SULLIVAN. *Chem. and Met. Eng.*, **22**, 29 (1920).—America has long been the acknowledged leader in ornamental cut-glass, no other country having equalled the brilliance and richness of the American product. An art glass which had its origin in America is the well-known Aurene or Favreuil glass, of golden iridescence, produced by spraying upon the surface of the finished article a liquid which reacts with the constituents of the glass and produces very remarkable soft color effects. Selenium red glass originated in this country and is used universally by railways in this country for the danger signal. In other railway signal glasses also this country is well in the lead, both in design of the semaphore lens and in production of the most efficient colors. Another advance due to America was the introduction of low-expansion so-called heat-resisting glass for railway lantern globes. For electric light bulbs non-potash glass has been in use for some years and in many respects gives better results than the potash

glass which it replaced. Two or three years ago a tank-melted bulb-glass was successfully introduced which contained neither potash nor lead, and its use has extended until a very large proportion of all lamp bulbs are now made of comparatively inexpensive materials. Selective Spectrum-Absorbing Glass. A very pale but brilliant yellow glass which absorbs ultra-violet almost completely has been developed. A recent American glass transmits ultraviolet and absorbs the visible. "Welders' glasses" have been worked out which absorb not only ultraviolet but also infra-red and such excess of the visible light as causes glare. Another unique glass absorbs only the infra-red. It is of pale green color and transmits most of the visible, but in thickness of only 2 mm. absorbs 95% or more of the invisible heat-rays. A glass for X-ray shields which had about one-third the protective power of metallic lead of the same thickness was developed during the war and was the most effective glass used for the purpose up to that time. Better chemical glassware is made in this country than was ever imported. The glass baking dish is a purely American development. American clay pots are giving in every respect fully as satisfactory service as was had from the imported material. H. P. NIXON.

Glass decolourizers and their influence. Schnurpfiel's Review for Glass Works, **3**, 499, 513 (1919).—The greenish tint in glass is due to iron compounds while the deepness of the tint depends upon the materials and the temperature of the furnace. The tint is neutralized by the use of nickel oxide, cobalt oxide, manganese oxide, antimony oxide, selenium and arsenic. Nickel oxide is most used. Requires 1 to 3 gr. per 100 kg. of sand and becomes effective at the end of the melt, due to its high melting point. Cobalt is often used with talcum and antimony. The yellow of the antimony offsets any excess of blue. Use $^1/_4$ to $^1/_2$ gr. of cobalt per 100 kg. of sand. Manganese gives a wine-red tint but may also give a yellow in soda glasses. Use 250 to 300 gr. for 100 kg. sand. The action is uncertain in tank furnaces. Antimony oxide is of doubtful value. When used it requires 220–250 grs. of antimony with an equal quantity of manganese for 100 kg. of sand. It is injurious to the pot as metallic precipitations settle at the bottom and corrode it. It increases the brilliancy of the glass. Satisfactory in tank furnaces. Selenium requires a high furnace temperature. Use 1–2 grs. per 100 kg. of sand. It is hard to get just the right amount. Arsenic clarifies the melt and oxidizes the carbon and sulphur compounds. Use 200 to 500 grs. or more per 100 kg. of sand. It boils at 412° C. causing active ebullition.

R. J. MONTGOMERY.

Water-glass, a colloidal method for increasing the volume of adhesive. J. D. MALCOLMSON. *J. Ind. Eng. Chem.*, **12**, 174 (1920).—Commercial silicate of soda of d. 42° Be is used in very large quantities in the fiber container industry, being now the only adhesive material employed for gluing double-faced corrugated board and laminated solid fiber board. A method has been found for increasing the vol. without injuring the essential properties

which make water-glass of especial value to the box-board industry. These properties are classed as follows: (1) Adhesive value; (2) proper viscosity; (3) low penetration; (4) fast setting and drying rate (the boards are run through the pasting machines at a speed of upwards of 60 ft. per min.); (5) relative insol. when dry; (6) relative flexibility when dry; (7) negligible effect of age; (8) relatively low cost. The method consists of dil. the water-glass with brine and it was found possible to increase the vol. of the soln. by 25% without loss of any of its essential properties. Water-glass is a complex mixture of sodium silicate, water and silica in the colloidal state. The adhesive grade usually contains 3–3$^1/_2$ parts of SiO_2 to 1 of Na_2O. When an electrolyte is added the colloidal silica is coagulated forming a "weakly agglutinated gel" which undisturbed coalesces to a dense mass; however, if this is stirred during the addition and for a short time afterwards the gel particles go back into "soln.," *i. e.*, "peptized." The peptization of the gel is accompanied by an enormous increase in viscosity over that which results from plain water dil. Twenty-five per cent increase in vol. was found to be the max. efficient amount; larger amounts of brine makes the peptization process increasingly difficult. The cost of treatment is low, since the treated water-glass contains only 3–4% by wt. of NaCl. F. GELSTHARP.

Glass and glassware, Japanese. O. P. HOPKINS. *J. Ind. Eng. Chem.*, **12**, 112 (1920).—Removal of Belgium, Germany and France from trade in Far East stimulated the Japanese industry. Increased imports from Japan consisted of beads and other glass. The increased exports from U. S. to Japan have been largely plate glass, formerly supplied by Europe. They have the advantage over competitors of low wages and laborers adapt themselves readily because of previous experience in pottery and similar lines. The av. daily wage for males being 38 cents and 17 cents for females. The SiO_2 used in a factory with a yearly production of 100,000,000 sq. ft. of window glass is obtained from Korea and Anam and is of excellent quality. The machinery in this factory is practically all driven by electric power.
F. GELSTHARP.

Glasses, the ultra-violet and visible transmission of eye-protective. K. S. GIBSON AND M. J. MCNICHOLAS. Bureau of Standards, *Tech. Paper* **119**.—A description is given of the method of making transmission measurements. Various instruments were used, including the Hilger sector apparatus, the Lummer-Brodhun and Koenig-Martens spectrophotometer and the Martens photometer. The samples studied were furnished by various dealers and represent most of the glasses used for spectacle purposes. They include akopas, amber, amethyst, arkweld, blue, chlorophile, chromatic test, cobalt, Crookes' crown 1.5, electric euphos, fieuzal, hollauer, laboratory, luxfel, noviol, noviweld, Pfund, rifleite, saniweld, smoke, welders. In most cases a number of shades are given. The table includes the company furnishing the sample, the color, the instrument used and the total transmission factor. Curves are given for 82 separate samples. R. J. MONTGOMERY.

Glass compositions. Schnurpfiel's Review for Glass Works, **3**, 915, 917, 919 (1919).

	Opal glass for blowing lbs.	Paste or strass glass lbs.	Plate glass lbs.	Plate glass lbs.	Window glass without salt cake lbs.
Sand	100	100	100	100	100
Carbonate of soda	28	..	34	20	34
Nitrate of soda	..	..	2	..	..
Sulphate of soda	..	..	..	21	..
Limestone	..	..	30	32	34
Arsenic	..	1	2	3	1/2
Feldspar	25	..	..	..	..
Fluorspar	18	..	..	..	..
Cryolite	6	..	..	..	..
Zinc oxide	4	..	..	..	..
Lead	..	100	..	..	..
Carbonate of potash	..	30	..	..	..
Nitrate of potash	2	9	..	..	..
Borax	..	2	..	..	..
Cullet	..	..	35	35	..
Charcoal	..	..	..	1	..
		oz.	oz.	oz.	
Manganese	..	2–3	4	5	..

R. J. MONTGOMERY.

Porcelain, glass-like, fusible. C. TOSTMANN, *Z. angew. Chem.*, **32**, 320 (1920).—The author claims that the Rosenthal Company has done nothing new in working porcelain-like glass, since Victor Meyer in 1885 worked a hard porcelain tube of the Royal porcelain works as glass, bending same and drawing it out to a capillary tube as is done with glass.

H. G. SCHURECHT.

PATENTS

Glass-working machine. F. L. O. WADSWORTH. U. S. 1,326,235, Dec. 30, 1919. The flow of molten glass from an orifice in the bottom of a tank to molds positioned thereunder is automatically regulated in synchronism with the movement of the molds. These molds are positioned upon the ends of radial arms which rotate in a vertical plane about a horizontal axis.

Glass-drawing, electrically-heated bait for. L. S. SKELTON. U. S. 1,326,296, Dec. 30, 1919. This bait is in the form of a hollow annulus having a circular slot in the bottom thereof. When the bait is dipped into the molten glass preparatory to making the draw, some glass flows into the bait through the slot and solidifies therein, forming a neck whereby the cylinder is drawn. In order to prevent undue chilling of the bait and to keep its interior at a uniform temperature, an electric-heating coil is placed within the upper part of the bait.

Glass, method of and apparatus for drawing hollow. C. P. BYRNES. U. S. 1,326,571, Dec. 30, 1919. By the use of concentric baits a plurality of cylinders are drawn simultaneously, with consequent increases in output and decrease in the loss of glass in the pots. One or both of the cylinders may be distended during the initial stage of the draw to increase their diameter to that desired.

Mold-press (for glass). W. J. MILLER. U. S. 1,326,765, Dec. 30, 1919. This press is designed for the production of glass caskets. A quantity of molten glass is introduced into a mold chamber, a cap ring is held against the top of the mold chamber, and a core is forced downwardly into the mold chamber to mold the interior of the casket and force the molten glass up between the walls of mold and the core until it reaches the cap ring.

Glass-drawing apparatus. W. WESTBURY. U. S. 1,326,241, Dec. 30, 1919. Drawing pot and bait are supported by a framework which is movable over the glass furnace. In the top of this furnace are draw openings into which the pot is raised and protected from the intense radiation from the furnace during the draw.

(**Glass**) **Pressing plunger mechanism** (**for**). W. J. MILLER. U. S. 1,326,365, Dec. 30, 1919. In machines for pressing glass articles the plunger is mounted in such a manner that it may be adjusted and aligned to center it with the mold or molds as they are presented.

(**Glass**) **Shear mechanism** (**for**). W. A. LORENZ. U. S. 1,326,460, Dec. 30, 1919. This invention relates to shear blades used in severing molten glass into drops or gathers to form charges. These blades have reentrant V-shaped cutting edges which approach each other toward the apices of the Vs. The blades are of relatively thin sheet steel and thus absorb very little heat.

Glass. C. R. PEREGRINE. U. S. 1,327,569, Jan. 6, 1920. A relatively dense white glass which may be used with thin shades and powerful illuminating elements and which does not show the dead white color characteristic of milk glass, is made by adding to 1500 parts of clear glass batch containing zinc oxide, 260 parts of aluminum hydroxide and 151 parts of sodium silicofluoride. Other aluminum containing compounds such as china clay and feldspar may be substituted for the aluminum hydroxide on the basis of aluminum present and other fluorides such as cryolite, sodium fluoride and fluorspar may be substituted for the sodium silico-fluoride on the basis of the fluorine present. Proportions may also be varied within limits.

G. E. MIDDLETON.

Whiteware and Porcelain

Bodies for spark plug insulators, preparation and composition of ceramic. A. V. BLEININGER. *Report* No. 53, National Advisory Committee for Aeronautics, pp. 25-31. In airplane engines the porcelain of the spark plugs is subjected to severe conditions, involving high temperatures,

sudden heating and cooling effects, and mechanical stresses. To be perfectly suited for the purpose, the material must remain a good electrical insulator at the maximum temperature reached, should not be subject to permanent volume changes, should possess constant thermal expansion, and must be strong and tough. Porcelains possessing such qualities have been developed in the Pittsburgh laboratory of the Bureau of Standards. The compositions in per cents of the best types are as follows: Porcelain, No. 152; Georgia kaolin, 10; Florida kaolin, 10; North Carolina kaolin, 10; Delaware kaolin, 10; Calcine No. 19, 40; Calcine No. 14, 20. The compositions in per cents of the calcines are: For calcine No. 19—kaolin, 70.20; alumina, 27.80; boric acid, 2.00. For calcine No. 14—kaolin, 56.00; magnesium carbonate (precipitated), 18.20; potters' flint, 25.80. For porcelain No. 194 the compositions in per cents are: Beryl, 35.0; Georgia kaolin, 12.5; Florida kaolin, 12.5; North Carolina kaolin, 12.5; Delaware kaolin, 12.5; potters' flint, 15.0. A. J. LAMBERT.

Feldspar as a pottery material. H. F. STALEY. *Brick Clay Record*, **56**, 335–338 (1920).—The feldspars may be roughly classed as potash feldspars, soda feldspars and lime feldspars. It is seldom that feldspars are found corresponding to these types as they are usually mixed with other feldspars and minerals. Potash feldspar occurs in two mineral forms, microline and orthoclase, the former being the more common.

ANALYSES OF COMMERCIAL GROUND FELDSPARS

S	1	2	3	4	5	6	7	8
SiO_2.....	76.37	65.87	65.73	69.05	69.45	65.50	68.20	71.07
Al_2O_3.....	13.87 (*a*)	19.10 (*a*)	19.28 (*a*)	17.40	16.76	21.17	18.17	16.23
Fe_2O_3.....	.....	.....	.....	.15	0.20	0.18	0.66	0.53
CaO.....	0.26	0.20	0.22	0.12	0.45	0.87	0.38	0.43
MgO.....	0.00	.....	.....	.....	0.45	1.40	0.26	0.24
K_2O.....	5.24	12.24	10.26	10.03	9.80	8.98	10.18	8.24
Na_2O.....	3.74	2.56	4.08	2.97	2.60	1.00	2.60	2.98
Loss on ignit...	0.30	0.64	0.48	.....	0.28	0.15	0.59	0.39

(*a*) Including small amounts of iron oxides.

1. Ground feldspar, No. 3 grade from near Bedford, N. Y. 2. Ground feldspar, No. 1 grade from Bedford, Ontario. 3. Ground feldspar, No. 1 grade from Auburn, Me. 4. Pennsylvania ground feldspar. 5. No. 2 potash feldspar from near Bedford, N. Y. 6. Soda feldspar. 7 and 8. No. 1 grade Maine feldspar showing maximum variations in five shipments.

The most practical solution of the feldspar problem for potters may be stated as follows: 1. The purchase of no feldspar of grade poorer than No. 2, from reputable producers, and insistence that the material be furnished up to grade. 2. The use of at least two brands of feldspar in each mix, the amount used of each brand being taken from two different shipments. 3.

Thorough testing in trial melts of each new shipment of feldspar to determine what change, if any, should be made in the mix to accommodate it to the new feldspar. Chemical analysis are not satisfactory for judging feldspar. Of the several minerals proposed as substitutes for feldspar, Cornwall stone is the most satisfactory. Its effects in pottery bodies are somewhat different from those of feldspar. H. G. SCHURECHT.

Filter presses, clothless. *Keram. Rundschau*, **28**, 30 (1920).—The German Ceramic Society awarded the first prize for inventing substitutes in filter presses to S. Schneider of Hennigsdorf for his tin plate patented filter press. It consists of a large vessel in which are stacked a large number of tin plates having a hollow center. These ring-like plates are pressed together with bolts. The slip is passed in the center of rings under a pressure and the liquid forced through very small ring-shaped spaces between the plates, leaving the filtered mass in the hollow center. The charge is removed from the apparatus automatically so the process is continuous. If the filter becomes clogged it can be easily cleaned by passing water through the same. The second prize was given to A. Zöllner, who developed a special paper which can be used successfully as a substitute for filter cloth. The third prize was given to B. Schwarz who invented porous plates to be used in the ordinary filter press. An inner plate has very coarse pores while the outer has extremely fine pores. A fourth prize was given to E. Rosenthal who developed a dry mixing process without using filter presses. The constituents are ground very fine and mixed thoroughly in a mixing machine, thereby doing away with the filter press. H. G. SCHURECHT.

Pottery manufacture, some unestimated losses in. *Pottery Gaz.*, **512**, 222-223 (1920).—Dr. J. W. Mellor and others. Care in the storage of clays is emphasized. In some cases specks in ware were traced to a rusty iron gas bracket in the storeroom which upon bumping caused a shower of rust to fall in the clay. Inefficiency of engines and boilers in potteries is common. In one case most of the men in a pottery were idle because there was not enough steam generated to run a pug mill. It was impossible to work the engine faster than 27 r. p. m. Upon consulting a competent engineer it was speeded up to 140 r. p. m. Bad stoking is another source of loss. Sending black clouds of smoke through the chimney is an unnecessary waste of fuel. At fully one-half of the potteries there is no attempt to make use of exhaust steam, although this is the best water for boilers. When a load of clay is delivered the floor should be cleaned before dumping, thus avoiding big losses, due to dirty clay. Well-regulated factories use $^3/_{10}$-inch wads, while in most of the factories $^7/_{10}$-inch wad clay is used, which is too thick. The weight of clay used in the latter case is five times more than was used in the first case and as a rule the loss due to "dirty" ware is increased. Thick wads also cause an increase in sagger losses. A saving of £1,000 may be obtained in one year in many plants by regulating the size of wad used. Gold otherwise lost in decorating processes may be recovered. Covering papers and rags

from the turn-tables and benches of the decorators are collected weekly. The gold is recovered by burning the paper and rags and treating the ash with a flux and oxidizing agent. An iron cauldron about 19 in. in diameter fitted with a stout wire grating about 1/2 inch mesh has been found to constitute a useful grate. On the top of this was fitted an iron cylinder with a lid. The dust remaining in the cauldron after the burning was collected and mixed with a flux and oxidizing agent as follows: Ash, 12 oz.; borax glass, 10 oz.; potassium nitrate, 2 oz. Borax glass is preferable to borax crystals and some people recommend covering the mixture with salt before firing in a kiln. A nugget of gold will be left in the bottom of the crucible. It is advisable to encase the crucible containing the mixture with an earthenware lining for safety. H. G. SCHURECHT.

PATENTS

Pulldown for potteries. G. LOWRY. U. S. 1,326,756. Dec. 30, 1919. The vertical arm which carries the shoe passes through rollers held on a horizontal arm. The vertical arm is curved in such a manner that the shoe descends into the center of the mold, but is then shifted into operative position at the side. In withdrawing the shoe it is similarly automatically moved to the center of the mold and then raised. G. E. MIDDLETON.

Cement and Lime

Effect of Fineness of Cement. DUFF A. ABRAMS. *Proceedings of A. S. T. M.*, **19,** Part II, pp. 328–424.—An investigation of the effect of fineness of cement has been under way for the past four years, through the coöperation of the Portland Cement Association and Lewis Institute at the Structural Materials Research Laboratory. The Portland cements used were from seven commercial mills. These plants represent the principal cement-producing districts east of the Mississippi River. Fifty-one different samples of cement were used. The cements were ground at the mill to four to seven degrees of fineness, which gave residues ranging from 2 to 43 per cent on the standard No. 200 sieve. In general, the aggregate consisted of sand and pebbles; in one series blast-furnace slag and a light-weight aggregate consisting of burnt shale were used. This report covers compression tests on 6125 6 × 12-in. concrete cylinders, 9000 compression and tension tests of mortar, and several thousand miscellaneous tests. Strength tests of concrete and mortar were made at ages of 7 days to one year. Conclusions from the tests: (1) There is no necessary relation between the strength of concrete and the fineness of the cement, if different cements are considered. (2) In general, the strength of concrete increases with the fineness of a given lot of cement, for all mixes, consistencies, gradings of the aggregate, and ages of concrete. The cements with residues lower than about 10 per cent were inclined to give erratic results in the strength tests. (3) For residues higher than 10 per cent the strength of concrete varies approximately inversely as the residue of the No. 200 sieve. (4) Fine grinding of cement is more effective in increasing the strength of lean mixtures than rich ones. (5) Fine grinding of cement is

more effective in increasing the strength of concrete at 7 days than at ages of 28 days to 1 year. (6) For the usual range of consistencies the effect of fineness of cement is independent of the consistency of the concrete. The rate of increase in strength with fineness is lowered for very wet mixtures. (7) Ordinary concrete mixtures at 28 days show an increase in strength of about 2 per cent for 1 per cent reduction in the residue of the cement on the No. 200 sieve. At 7 days, 3 months and 1 year the corresponding increases in strength are about 2.5, 1.7 and 1.4 per cent. (8) The decreased benefit of fine grinding of cement with the age of the concrete does not bear out accepted opinion that the coarser particles of cement do not hydrate, but indicates that the principal result of finer grinding is to hasten the early hardening of the concrete. (9) For the richer mixtures and the consistency necessary for building construction, the fineness of the cement has no appreciable effect on the workability of concrete as determined by the "slump" test. For leaner mixtures and wetter consistencies, the finer cements showed a somewhat greater "slump" than the coarser cements. (10) The normal consistency of cement is increased with fineness of grinding. About 0.1 per cent of water (in terms of the weight of the cement) must be added for each 1 per cent reduction in residue on the No. 200 seive. (11) The time of setting of the cement is shortened with finer grinding. (12) The unit weight of cement decreases with fineness. For the cements used in these tests the weight varied from 76 (residue of 2.4 per cent) to 108 lbs. per cu. ft. (residue 43.3 per cent). For the usual range in fineness the weight is lowered about $^3/_4$ lb. per cu. ft. for each 1 per cent reduction in the residue on the No. 200 sieve. (13) In using 94 lbs. per cu. ft. as a uniform basis for proportioning the cements in these tests, the actual volume of cement in a batch *of the same mix* varies about 35 per cent. If the mixtures had been proportioned in a manner that would have given a uniform *volume* of cement, the resulting concrete strength would not have been so favorable to the finer cements. (14) The fineness of cement has no appreciable effect on the yield or density of concrete. (15) Concrete of all mixes and consistencies showed expansion in damp sand or water storage and contraction in air. (16) The change in length of concrete specimens stored in air or water is independent of the fineness of the cement and the consistency of the concrete. The lean concretes are slightly less affected than the rich mixtures. (17) The type of aggregate has little or no influence on the relative effect of fineness of cement on the strength of concrete. (18) The tests included in this report show an intimate relation between the strength of the concrete and the water-ratio of the mixture. The lower the water-ratio (so long as the concrete is plastic and the aggregate not too coarse) the higher the strength, and *vice versa*. This confirms the results of other concrete tests made in this laboratory. Increasing the quantity of cement in a given mixture enables us to secure a concrete of equal workability with a lower water-ratio, hence a higher strength. (19) In ordinary concrete mixtures (say 1 : 5 to 1 : 4, requiring 20 to 25 per cent cement by volume) increasing the cement content by 1 per cent (to 20.2 per cent for a 1 : 5 mix)

gives an increase in strength of about 1 per cent. (20) One per cent increase in cement is more effective in increasing the strength of concrete in lean than in rich mixtures. (21) One per cent increase in cement is somewhat more effective in increasing the early strength of concrete than at later periods. (22) The effect of increasing the quantity of cement is independent of the consistency of the concrete. (23) Tension tests of briquettes do not give a correct measure of the relative merits of different cements as determined by compression tests of mortar and concrete. A. J. LAMBERT.

Cements producing quick-hardening concrete. P. H. BATES. *Proceedings A. S. T. M.*, **19**, Part II, 425–438.—There have been prepared at the Pittsburgh Branch of the Bureau of Standards certain cements which have the property of hardening very rapidly. These were made in a manner no different from that used in making Portland cement. Their composition differed very materially from the composition of the latter, in that they were composed very largely of lime and alumina. These calcium aluminates, when they are very high in alumina, do not have a very marked rapid initial set, but do harden very quickly and therefore produce high early strengths. Some of the maximum strengths were 3145 lbs. per sq. in. for 1 : 6 gravel concrete tested in the form of a 6 × 12-in. cylinder at the end of 24 hours, 6010 sq. in. at the end of seven days, and 8220 lbs. per sq. in. at the end of one year. "Sorel cements" are those produced by gaging light calcined magnesia with magnesium chloride solution. Such a cement develops in 24 hours a strength approximately equivalent to that developed at the end of seven days by a similar concrete made with Portland cement. Both of these cements commend themselves for certain special uses, where a quick-hardening concrete of high strength is desired. Neither would be desirable where subjected to the continued action of water. The Sorel cement alone is on the market at the present time. A. J. LAMBERT.

Cements for spark-plug electrodes. H. F. STALEY. Bur. Standards, *Tech. Paper* **155**. A. J. LAMBERT.

PATENTS

Cementing material obtained from greensand. H. W. CHARLTON. U. S. 1,327,145, Jan. 6, 1920. A greenish or brownish white material containing silicates of iron, calcium and aluminum, is obtained by digesting greensand with lime. This material when freshly made is plastic and self-hardening and is capable when heated with steam of undergoing a still further hardening process. G. E. MIDDLETON.

Abrasives

PATENTS

Abrasive wheel, lubricating, and method of making it. L. L. KATZENSTEIN. U. S. 1,325,503, Dec. 16, 1919. The abrasive wheel is heated to a temperature

above that of the filler to be used and immersed in a molten bath of this filler to impregnate the pores of the wheel. The wheel is then removed, and while the filler is still molten, rotated to remove the excess centrifugally. A combination of paraffin and rosin is given as a specific example of the filler used.

Abrasive tool and process of making it. C. R. KING. U. S. 1,325,504, Dec. 16, 1919. A so-called "elastic" abrasive wheel or tool comprising abrasive grains bonded by a bond comprising shellac and plaster of Paris, the proportions being 12–30 per cent shellac, 3–20 per cent plaster of Paris, and the rest abrasive. G. E. MIDDLETON.

ACTIVITIES OF THE SOCIETY

Important Actions Taken by the Board of Trustees at Meetings Held during the Annual Meeting at Philadelphia, February 23–26, 1920

It was voted to recommend to the Committee on Publications that 2200 copies of each issue of the JOURNAL be printed in 1920.

It was voted that the reinstatement of German members be put upon the same basis as that of other members in arrears.

It was voted that the Secretary be instructed to send the JOURNAL, beginning with Vol. 1, to the library of Louvain, Belgium, and also a copy of Branner's "Bibliography of the Ceramic Arts."

It was voted that President Stull should recommend to the new President the appointment of Colonel Orton as chairman of the committee on the visit of the English Ceramic Society.

It was voted that members in arrears for two years should be communicated with once more, and, if dues then remained unpaid, the members should be dropped from the rolls of the Society.

It was voted that notice be given of a change in rule pending, to the effect first, that the annual dues of Active and Associate Members, respectively, shall be fixed by the Board of Trustees but shall not exceed ten dollars, the privileges of membership to begin upon payment of the annual dues; second, that the annual dues of Active, Associate, and Corporation Members shall be due and payable on January first each year.

One-hundred and eighteen Associates were elevated to Active Membership.

It was voted to authorize the Treasurer to invest $5000 in government bonds.

It was voted that one copy of the Collective Index to the Transactions should be available to each member of the Society at a charge of fifty cents and that a letter to this effect be sent to all members. Also that the price of the Index to non-members shall be $1.50.

It was voted that Chas. F. Binns be appointed Secretary of the Society for the fiscal year, beginning January 1, 1920, at a salary of $1000 per annum.

It was voted that Norah W. Binns be re-appointed Assistant Secretary for the fiscal year, beginning January 1, 1920, at a salary of $1200 per annum.

ASSOCIATE MEMBERS ELEVATED TO ACTIVE MEMBERSHIP, FEB. 26, 1920

Allen, F. B.	Back, Robert	Bellamy, H. T.
Applegate, D. H., Jr.	Balmert, R. M.	Binns, Norah W.
Arbogast, F. J.	Balz, Geo. A.	Blackmer, E. L.
Ayres, E. B.	Bartells, H. H.	Blewett, J. B.

Boughey, Joseph
Bowman, O. O., 2nd
Brewster, Robert
Breyer, F. G.
Brower, Fred
Brown, L. K.
Brownlee, W. K.
Burroughs, F. H.
Butterworth, F. W.
Cheney, M. B.
Chormann, O. I.
Christmann, C. E.
Claudon, C. F.
Cooke, R. D.
Coors, H. F.
Covan, H. E.
Crane, C. W.
Davenport, R. W.
Dean, C. A.
DeVoe, Chas. H.
Dickey, Fred L.
Dinsmore, B. B.
Dobbins, T. M.
Dunn, F. B.
Ebinger, D. H.
Edgar, D. R.
Eskesen, B. K.
Fisher, D. J.
Fisher, Geo. P.
Forst, A. D.
Frazer, W. B.
Fraunfelter, C. D.
Freese, H. H.
Fulweiler, W. H.
Gahris, W. I.
Gates, A. W.
Gates, M. E.
Geiger, Chas. F.
Gibbs, A. E.
Gladding, A. L.
Grant, De Forest
Green, J. L.
Haley, M. A.
Hall, C. A.
Hardy, I. E.
Harker, H. N.
Hasburg, J. W.
Hastings, F. N.
Hatton, R. D.
Ittner, Warren
Johnston, John
Keplinger, R. B.
Kimble, H. K.
Kleymeyer, H. C.
Knollman, H. J.
Krick, G. M.
Laird, J. S.
Larkin, P. G.
Layman, F. E.
Lillibridge, H. D.
Linder, C. S.
Longenecker, H. L.
Lucas, H. J.
Maddock, H. E.
Malm, A. T.
Maltby, Alfred
Martens, Paul
Martz, J. A.
Miner, H. S.
Mueller, Theo.
Munshaw, L. M.
McBean, Atholl
McCann, J. S.
McCoy, Wm.
McDanel, W. W.
McVay, T. M.
Oudin, C. P.
Paterson, Alexander
Pettinos, G. F.
Powell, W. H.
Purington, B. S.
Rainey, L. B.
Rand, C. C.
Reed, Henry M.
Rice, B. A.
Rodgers, Eben
Roessler, Franz
Ross, D. W.
Saunders, W. E.
Schory, V. S.
Sinclair, Herbert
Smith, W. L., Jr.
Springe, Otto
Sproat, Ira
Stanger, Frederick
Stevens, D. F.
Stowe, C. B.
Tefft, C. F.
Thompson, D. D.
Tilton, Earl
Van Schoick, E. H.
Vodrey, W. E.
Whitaker, F. A.
Whitehead, Fred
Whitmer, J. D.
Wright, J. W.

Notice

The Edgemont Feldspar Company is no longer in the feldspar business, and persons holding the Directory of Dealers should delete the name.

New Members Received during March

Resident Associate

Albery, D. F., Chemist, Federal Terra Cotta Co., Woodbridge, N. J.
Amsler, W. O., D. Sc., President, Amsler-Morton Co., Pittsburgh, Pa.

Barlow, Alfred, Superintendent, Golding Sons Co., Wilmington, Del.
Bauer, James L., Assistant Secretary and Assistant Treasurer, New England Enameling Co., Middletown, Conn.
Betteley, Albert G., Superintendent, Process Laboratory, Jeffery-Dewitt Co., Detroit, Mich.
Bickel, Earl A., Assistant to Manager, Postville Clay Products Co., Postville, Iowa.
Blum, John W., 181 West Tenth Ave., Columbus, Ohio.
Borg, H. E., 2122 Lincoln Way, Ames, Iowa.
Borkey, J. H., District Sales Agent, Elk Fire Brick Co., Land Title Bldg., Philadelphia, Pa.
Brenholtz, W. K., Foreman, Clay Preparation Dept., Champion Ignition Co., Flint, Mich.
Brian, Chas., General Manager, Clay Dept., Paper Makers Chemical Co., Easton, Pa.
Brian, George, Salesman, Paper Makers Chemical Co., East Liverpool, Ohio.
Bridge, Laurence D., Bridge & Beach Mfg. Co., St. Louis, Mo.
Brown, Leslie, Lenox, Inc., Trenton, N. J.
Burt, F. M., Superintendent, Enameling Dept., Saho Stamping Co., Earsel, W. Va.
Cameron, A. C., Manager, North East Fire Brick Co., North East, Md.
Corl, Robert M., 328 Bank of Commerce Bldg., Toledo, Ohio.
Coxon, J. Frederick, President, Wooster Sanitary Mfg. Co., Fredericksburg, Ohio.
Cramer, W. E., 213 East South St., Fostoria, Ohio.
Dennis, J. Alfred, Superintendent, Golding Sons Co., Trenton, N. J.
Dressler, Conrad, American Dressler Tunnel Kilns, Inc., New York City.
Emminger, Thos. F., General Superintendent, Pittsburgh Clay Pot Co., Pittsburgh, Pa.
Flagg, Frederick P., Chief Chemist, Waltham Watch Co., Waltham, Mass.
Foltz, Andrew, President, Lambertville Pottery Co., Lambertville, N. J.
Frantz, Samuel G., Crossett Lumber Co., Crossett, Ark.
George, J. S., Bureau of Standards, Pittsburgh, Pa.
George, W. C., Vice-President, W. S. George Pottery Co., East Palestine, Ohio.
Godejohn, W. F., Laclede-Christy Clay Products Co., St. Louis, Mo.
Goodman, A. H., Sales Engineer, Blaw-Knox Co., Pittsburgh, Pa.
Gray, Arthur E., Treasurer and General Manager, Pittsburgh Clay Pot Co., Pittsburgh, Pa.
Greenwood, John L., Superintendent, Lehigh Sewer Pipe and Tile Co., Lehigh, Iowa.
Gunther, Franklin W., 187 Twelfth Ave., Columbus, Ohio.
Guthrie, Lee, Foreman, Elyria Enameled Products Co., Elyria, Ohio.
Harker, O. A., Jr., President and Manager, Dixie Brick and Tile Co., Puryear, Tenn.

Hill, Charles W., General Works Manager, Atlantic Terra Cotta Co., Perth Amboy, N. J.

Jaeger, Frank G., Superintendent, Buck Stove and Range Co., St. Louis, Mo.

Jones, Richard E., 1886 N. Fourth St., Columbus, Ohio.

Kraus, Lysle R., Secretary, Kraus Research Laboratories, Inc., New York City.

Lindsay, Robert F., Denver Fire Clay Co., Denver, Colo.

Maddock, John B., John Maddock & Sons, Trenton, N. J.

Minton, Gerald Z., 1842 Indianola Ave., Columbus, Ohio.

Moore, E. S., Ph.D., Dean, School of Mines, Pennsylvania State College, State College, Pa.

Nagle, J. A., Superintendent, Brunt Tile and Porcelain Co., Columbus, Ohio.

Nagle, Michael F., Superintendent, South Amboy Terra Cotta Co., South Amboy, N. J.

Pendrup, W., Superintendent, Enameling Dept., Coonley Mfg. Co., Cicero, Ill.

Philips, Wilson A., President, Philips-Harper Co., Trenton, N. J.

Polk, A. E., 1104 W. Oregon St., Urbana, Ill.

Ritschy, Donald P., Empire China Works, Brooklyn, N. Y.

Roll, Edward E., 1037 Ansel Road, Cleveland, Ohio.

Sebring, F. H., Jr., President, The Salem China Co., Salem, Ohio.

Smith, Wilbur R., Superintendent, Illinois Glass Co., Alton, Ill.

Stull, Jos. M., Ceramist, O. W. Ketcham Terra Cotta Works, Crum Lynne, Pa.

Trood, Samuel, Vice-President and General Manager, U. S. Sherardizing Co., New Castle, Pa.

Van Moore, A. L., American Window Glass Co., New Eagle, Pa.

Vincent, Harry S., President, Vincent Clay Products Co., Fort Dodge, Iowa.

Watkins, Ray T., Bureau of Mines, Columbus, Ohio.

Whittemore, John W., 2166 Lincoln Way, Ames, Iowa.

Woodams, Wilbur G., Manager Industrial Relations, Hawk Eye Works, Eastman Kodak Co., Rochester, N. Y.

Wright, John M., Secretary-Treasurer, Golding Sons Co., Trenton, N. J.

Yung, W. A., Glass Technology Dept., National Lamp Works, Cleveland, Ohio.

Zwerner, Carl G., 58 West Tenth Ave., Columbus, Ohio.

Foreign Associate

Cole, G. Percy, Technical Engineer, Dominion Glass Co., Ltd., Montreal, Canada.

Gardner, W. J., Managing Director, The Meltham Silica Fire Brick Co., Ltd., Meltham, near Huddersfield, England.

Kelkar, G. D., Department of Glass Technology, The University, Sheffield, England.

Meldrum, A. T. S. C., Vice-President, Canadian Hart Products, Ltd., Hamilton, Canada.

Ogale, G. P., Department of Glass Technology, The University, Sheffield, England.

Van Overstraeten, Jean, Societe Generale de Carrelages et de Produits Ceramiques, 3, Rue d'Edimbourg, Paris (VIII e), France.

Varshnei, B. D., Department of Glass Technology, The University, Sheffield, England.

Corporation

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Coonley Mfg. Co., Cicero, Ill.

Gillinder Bros., Port Jervis, N. Y.

Philadelphia Drying Machinery Co., Philadelphia, Pa.

Reliance Firebrick & Pottery Co., Ltd., Chanch, Barakar P. O., East India Railway, India.

Standard Sanitary Mfg. Co., Bessemer Bldg., Pittsburgh, Pa.

Necrology

FRITZ WAGNER.—In the passing of Fritz Wagner the terra cotta industry has suffered a great loss. He was a remarkable man, always resourceful, always vigorous, always just. He possessed a wonderful personality which, coupled with his thorough knowledge of the architectural profession as well as his own particular line, assured him lasting place in the profession.

For many years he was a welcomed adviser on material and construction in the best architects' offices, thereby doing more to increase the use of his material than was ever done by any man or group of men. He always stood strong for the best possible material and he always stood by his material, saw that it was right and that it was used right. His acquaintance among the architects was very wide and they, very properly, had absolute confidence in him. He has left the mark of his individuality indelibly impressed on buildings all over the United States, and these shall stand as a monument to his intelligence and sterling integrity.

In more than thirty years of closest competition, I can recall no unkind or questionable act between us. I know him as few others did and he won my admiration, esteem and love, and I sincerely mourn his passing. WM. D. GATES.

MR. IDRIS NELSON.—After graduating from the University of Illinois, Mr. Nelson entered the service of the Purington Paving Brick Company as a ceramic engineer in the Fall of 1913. A year later he returned to the University of Illinois and took a graduate course in ceramics, returning to the employ of the same company. He rose to the position of Assistant General Superintendent. He died January 27th, 1920, of pneumonia, after an illness of about a week.

Mr. Nelson was a very efficient and capable engineer and had a bright future. He was a member of the American Ceramic Society, Masonic Fraternity and Elks Lodge. Mr. Nelson was married in June, 1917.

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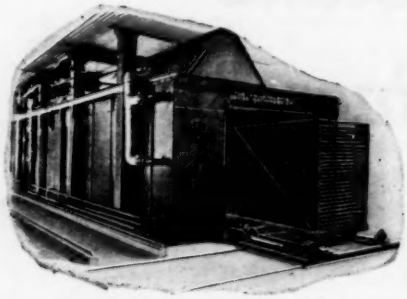

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Fourth:—The cooling of the ware as well as the water-smoking and pre-heating in this kiln are absolutely automatic. It is impossible to get the receiving end of the tunnel too hot.

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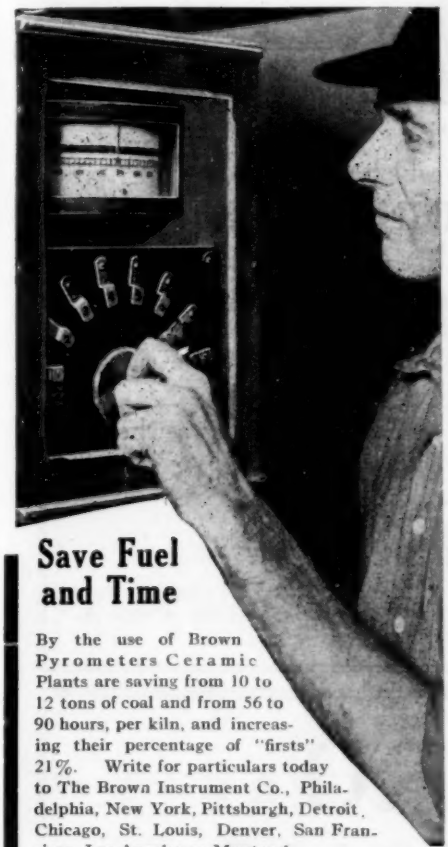

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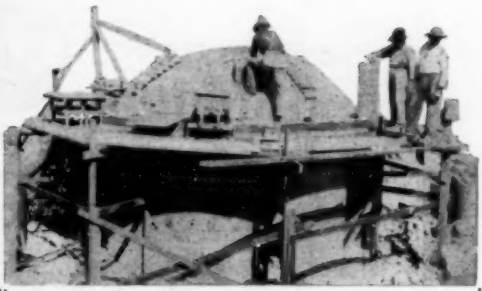

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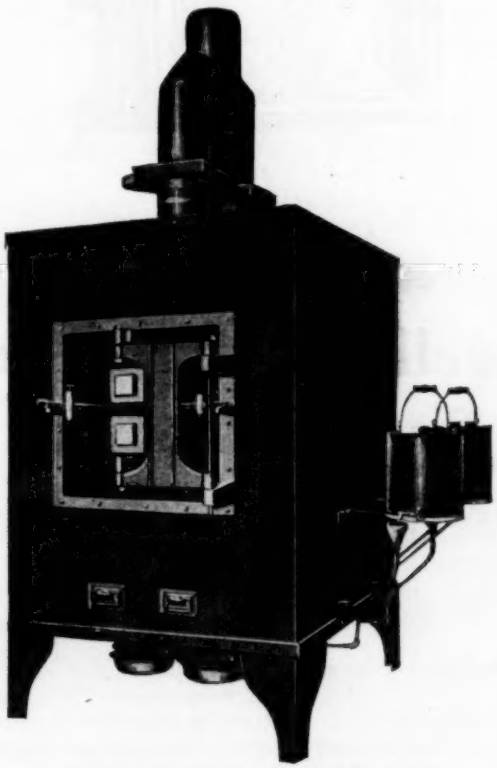

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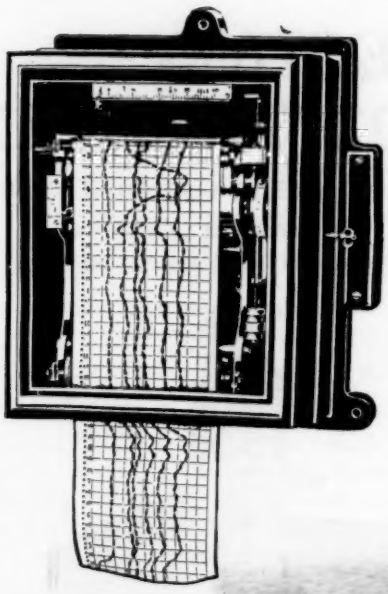

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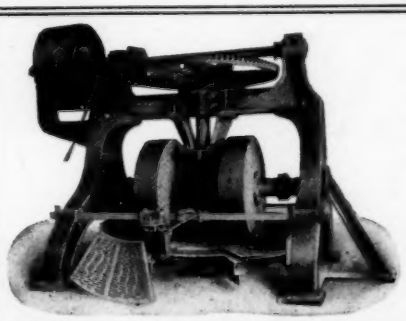

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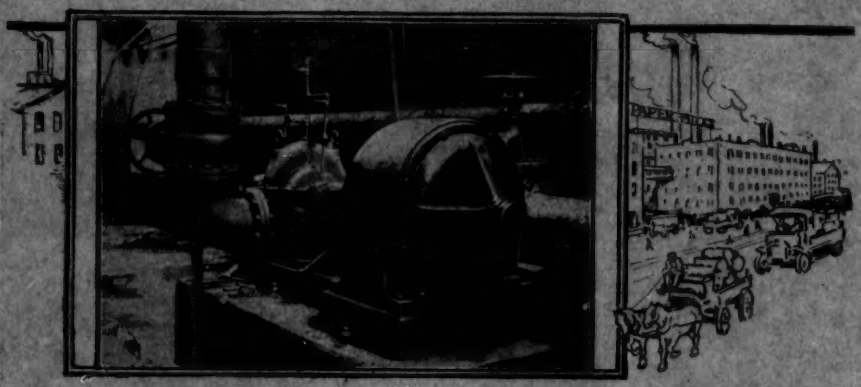

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